ELEMENTARY BUILDING CONSTRUCTION AND DRAWING

BURRELL

Longmans' Elementary Science Manuals.

BUILDING CONSTRUCTION AND DRAWING

ELEMENTARY

BUILDING CONSTRUCTION AND DRAWING

STAGE I

BY

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PREFACE.

THIS book, which has been compiled from Notes of Lectures delivered to the Day Students of the People's Palace Technical Schools, is intended for the use, more particularly, of those preparing for the examination in Elementary Building Construction and Drawing conducted by the Science and Art Department.

The object in introducing the present work is to meet the growing demand for a suitable text-book, published at a price such as will bring it within the reach of all.

One has only to note the rapid strides which are now being made in technical education in order to realise that such a demand really exists.

The chief aim of the writer has been to place before the student numerous examples of constructive details, which shall not only serve as illustrations to the text, but shall also afford the data necessary for making scale drawings of the various parts. With this end in view the diagrams have been carefully dimensioned.

The writer trusts that this feature will recommend itself forcibly to teachers. The association, in the same volume, of dimensioned drawings with the text cannot but prove convenient.

Brief notes on the selection of drawing instruments and materials, as well as instructions for setting out, inking, colouring, and finishing, working drawings will be found in the introductory chapter.

At the end of each chapter is given a large number of exercises (amounting in all to 320) bearing directly on the subject-matter of that chapter.

Some of these are connected with the diagrams illustrating the text. Others have been gleaned from the Examination Papers of the Science and Art Department, and at the end of the book will be found *in extenso* the questions which have been proposed at the May examinations in the years 1890 to 1903. The attention of the student is particularly directed to these exercises, serving as they do to test the grip which has been obtained on the subject.

With each is mentioned a scale, the use of which will be found to bring the drawing within the limits of a sheet of drawing paper of ordinary size.

The signs ′ and ″ are employed in this work to represent *feet* and *inches* respectively, 6′ 3″ being read 6 feet 3 inches.

It is usual in practice to indicate a measurement of say 9 feet thus : 9′ 0″.

This plan has not, however, been carried out in the following pages. A dimension such as that just referred to is indicated thus : 9′.

In figuring *working drawings* the student is advised to employ the former method, since it is then quite apparent to the workman that the measurement intended is 9 feet. In the second case there is a possibility of the length being more than that represented, the draughtsman having failed to insert the number of inches.

The writer gladly takes this opportunity of recording his indebtedness to Mr. J. Nixon Horsfield, of Surbiton, an architect of many years' standing, for his kindly assistance in passing this book through the press. Several of the illustrations and notes have been inserted at his suggestion.

Mr. Thomas Bremner, one of the masters of the People's Palace Technical Schools, has also placed the writer under great obligations for the valuable aid he has rendered in correcting the drawings.

The Publishers have to acknowledge the permission kindly granted by the Controller of H.M. Stationery Office to reprint the Board of Education Examination Papers at the end of this book.

E. J. B.

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BUILDING CONSTRUCTION.

CHAPTER I.

INTRODUCTORY REMARKS ON DRAWING INSTRUMENTS AND MATERIALS, HINTS ON DRAWING, INKING, AND COLOURING, ISOMETRIC PROJECTION.

1. **Drawing instruments and materials.**—In purchasing these the student is advised to shun trashy articles, which, though cheap, are invariably **nasty**, and worse than useless. It is hopeless to expect good work from bad or indifferent tools. With regard to **mathematical instruments**, the better plan, if cost be an object, is to lay out the money at disposal in the purchase of a **few really good instruments** (which may always be obtained secondhand) rather than to provide an elaborate box of instruments, some of the pieces in which will doubtless never be required at all.

The following should be provided :—

(1) A **pair of 6″ compasses** with **pen** and **pencil** points.

(2) A **pair of dividers.**

(3) **Spring bows** for **pencil** and **ink** to be used for small circles.

(4) A **drawing pen** for inking in the pencil lines.

(5) A **drawing board**, about $24'' \times 16\frac{1}{2}''$, well seasoned and clamped at the back to prevent warping.

(6) A **T-square,** the same in length as the board.

(7) **45° and 30° set squares.** These should be made of pear tree this material being more cleanly in use than ebonite.

The latter, owing to its electrical properties, readily picks up any dust lying about, which is then transferred to the drawing.


FIG. 1.

(8) **Lead pencils**, marked H and HB, the former for lines intended to be inked in. These should be brought to a chisel point as in fig. 1.

The quantity of lead required to form a line being taken from an **edge** instead of a **point**, will not blunt the former so much as it would the latter.

A **piece of fine glass paper,** glued to a strip of wood, is a handy means of restoring the keenness.

(9) **French curves**, for forming curves where the use of compasses is inadmissible.

(10) **Indian ink**. This should be of the finest quality, and free from grittiness, which is fatal to clear lines. Common writing ink must not be used, since it rapidly corrodes and spoils the drawing pen.

(11) **A few cakes of water colour**.—A table will be found further on in the present chapter, which gives a list of the tints required for ordinary use.

(12) **Sable or camel-hair brushes** for laying on the colour.

(13) **Drawing paper**.—The kind known as **Cartridge** paper is generally used, though hand-made paper is better. This may be obtained in sheets of various sizes, which can be fastened to the board with **drawing pins** or **paste**. If the latter be used, the back of the sheet must be **damped**, pasted at the edges, and laid smoothly on the board. When dry it will be found tightly stretched. The paper may be removed from the board by cutting it away from the adhering portion.

2. Scales.—The following scales will be required for working the exercises contained in this book :—

A scale of full size.

"	$\frac{1}{2}$ size, or	6	inches to	1	foot
"	$\frac{1}{3}$ "	4	"		"
"	$\frac{1}{4}$ "	3	"		"
"	$\frac{1}{6}$ "	2	"		"

A scale of	$\frac{1}{8}$ size	or	$1\frac{1}{2}$ inch	to	1 foot
,,	$\frac{1}{12}$	,,	1	,,	,,
,,	$\frac{1}{24}$	,,	$\frac{1}{2}$	,,	,,
,,	$\frac{1}{48}$	,,	$\frac{1}{4}$	,,	,,

Scales are usually made of ivory or boxwood. The former material, though the more durable, is very expensive.

For all ordinary purposes cardboard scales may be used. These are very cheap, and if varnished will last a long while.

In every case the division should be marked down to the edge of the scale, so that by applying it directly to the drawing accuracy may be ensured and time saved. Measurements should never be taken from a scale by means of dividers and then transferred to the paper.

3. The pencil drawing.—This, if intended to be inked in, should be done with a moderately hard pencil, brought to a chisel point as before mentioned, the round point being reserved for freehand work. In setting out a drawing the method must be adopted of commencing with the general outline and working from centre lines. Details should be an after-consideration. When from the nature of the drawing no particular line can be selected about which it is symmetrical, the

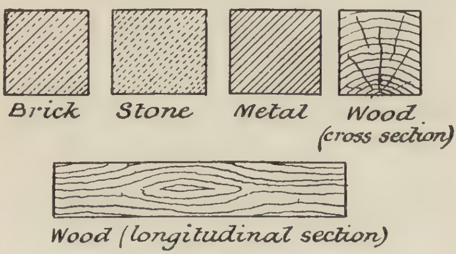


FIG. 2.

student should begin with that portion which from size and position appears the most prominent. As a rule, those members which are structurally of greatest importance should be attempted first.

In using the T-square the butt or cross-piece should be kept at, and moved along, the left-hand edge of the drawing-board. Perpendicular lines are drawn by placing the set

square with its edge resting on that of the T-square. The pencil lines must be done as lightly as possible if intended to be inked in. If the lines are to be left in pencil they should be bolder. Parts in section may be indicated as shown in fig. 2.

The above system of section lining is adopted in this work.

4. **Inking in the drawing.**—If the stick Indian ink be used, it must be rubbed down in a palette with water, taking care to dry the stick immediately after, or it will work gritty when next used and will run if coloured upon. Prepared liquid Indian ink may, however, be obtained. A sufficient quantity being placed in the pen by means of **a narrow slip of paper** (which soon becomes saturated, and is then superior to a brush for this purpose), the pencil lines should be carefully gone over, the pen being held **nearly upright**, with its two nibs resting fairly on the paper. Lines with ragged edges will thus be avoided. If the pen becomes clogged, as it frequently does, from taking up the lead of the pencil lines, it may be cleaned by drawing between the nibs a slip of paper, which removes the obstruction. In order to form a neat junction between a straight line and a curved one, it will be found better to first ink in the latter. The section lines must be omitted if the drawing has to be coloured.

5. **Colouring the drawing.**—In some drawing offices it is the practice to colour every portion of a drawing, the parts cut by planes of section being distinguished by darker tints.

The result is certainly effective, but the student is advised to aim at the execution of **clear, easily understood, working drawings** rather than at the production of **highly-coloured pictures**. It should be remembered that in using colour the primary idea is the **indication of materials** used in construction. Generally it will be sufficient to tint **parts in section**. Timber in full plan or elevation may be coloured in some cases with advantage.

The following table gives the colours generally used to indicate particular materials.

Material.	Colour.
Wrought iron . .	Prussian blue.
Cast iron . . .	Payne's grey or neutral tint.

Material.	Colour.
Steel	Purple (indigo with a little crimson lake added).
Brass	Gamboge with a little burnt sienna added.
Lead	Neutral tint, or Indian ink with a little indigo added.
Stone (elevation) . .	Yellow ochre or gamboge with a little Indian red and burnt sienna added.
Stone (section) . .	Light sepia or light Indian ink with a little Prussian blue added.
Brickwork (elevation) .	Crimson lake with a little Indian red or burnt sienna added.
Blue bricks . . .	The same with a little Payne's grey added.
Brickwork (section) .	Crimson lake.
Brickwork (removed by alterations) . .	Outlined in Prussian blue.
Concrete . . .	Sepia or Payne's grey.
Earth	Burnt umber or sepia jagged at the edges.
Fir and soft woods .	Burnt sienna, or gamboge with a little yellow ochre added.
Hard woods . .	Burnt sienna with a little red added.
Oak	Vandyke brown.
Glass . . .	Green or Prussian blue.
Plaster	Payne's grey.
Slates	Payne's grey, or neutral tint with a little crimson lake added.
Tiles	Brown madder.

It is of the utmost importance to lay on the colour in **a flat wash** commencing at the upper part and spreading it downwards as equally as possible over the whole work.. In order to do this properly, **a large brush** must be used. Small brushes give a streaky appearance to the colouring. The colour must also be thin. **A darker tint** can always be secured by washing it over again **when dry**. A good plan, when colouring large surfaces, is to first **damp the paper** with water, any superfluous moisture being taken up by blotting-paper.

6. Finishing the drawing.—The **centre lines** may now be inserted. These are generally shown as **full lines** put in with **red** ink. The **dimension lines** should next be drawn with **blue ink** ; the **arrow heads** and figures being marked in **black.** A word or two with regard to the insertion of dimensions. Much labour is saved to those who have the reading of working drawings, if the sizes are carefully and systematically

marked. Inaccuracy is frequently the result of a workman having to apply his rule to a drawing, especially if it be drawn to a small scale. The following points should be noticed :—

(1) All figures should read from the bottom or right hand side of the paper.

(2) Over-all dimensions should be given in order to check a number of smaller ones.

The examples appended illustrate this.

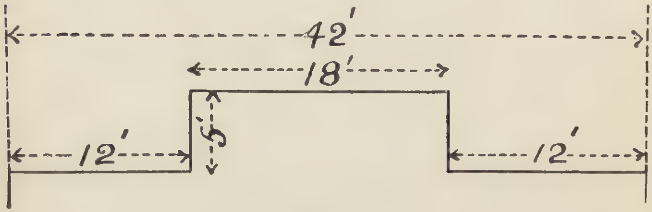


Fig. 3.

Lettering.—Several styles of letter are used for this purpose. The **title** of the drawing and the designation of each view shown—e.g. **plan, elevation, section, sectional elevation, sectional plan,** etc.—may be printed in the following style, which is plain and not difficult of execution.

A B C D E F G H I J K L M N O P
Q R S T U V W X Y Z,
1 2 3 4 5 6 7 8 9 0.

Names of parts and **general remarks** may be inserted in the following style :—

a b c d e f g h i j k l m n o p q r s t u v w x y z,
1 2 3 4 5 6 7 8 9 0.

Architects are in the habit of using a more artistic style of lettering on their drawings.

The following is an example :—

ABCDEFGHIJKLMN
OPQRSTUVWXYZ,
abcdefghijklmnopqrstuvwxyz,
1234567890.

Lastly, a **neat border** line may be put round the drawing for the purpose of adding a finish.

7. Isometric projection.—The student will notice as he proceeds with his drawing, that in order to give a correct notion of the form of an object, **two views** at least, taken from different points, are necessary. Generally one of these views is taken in a direction **at right angles to the horizontal plane,** the other **at right angles to some vertical plane.** The former is termed **a plan,** the latter **an elevation.** In certain cases a **second elevation** is added.

There is, however, a method of representation termed **isometric projection,** in which **one** view only suffices to give a complete idea of the form of an object.

It is particularly adapted to those cases in which the principal lines are **mutually perpendicular.** This system, therefore, lends itself very readily for the purposes of building drawing. No attempt can be made in a text book of this description to investigate the theory upon which it is based.

The student will find the subject admirably treated in Low's 'Practical Plane and Descriptive Geometry,' Part II., published in this series.

Suffice it to say that all the lines of a solid which are perpendicular to one another, or are parallel to three lines mutually perpendicular, are in isometric projection drawn **parallel to three straight lines** or **axes,** *a b c*, fig. 2, which are obtained in the manner indicated.

Another great advantage is that, unlike perspective, in which the object as it recedes into the distance is diminished, all lines of the projection can be measured by **the same scale.**

This renders it peculiarly adapted for workshop purposes. Fig. 4 shows an isometric projection of a wooden girder

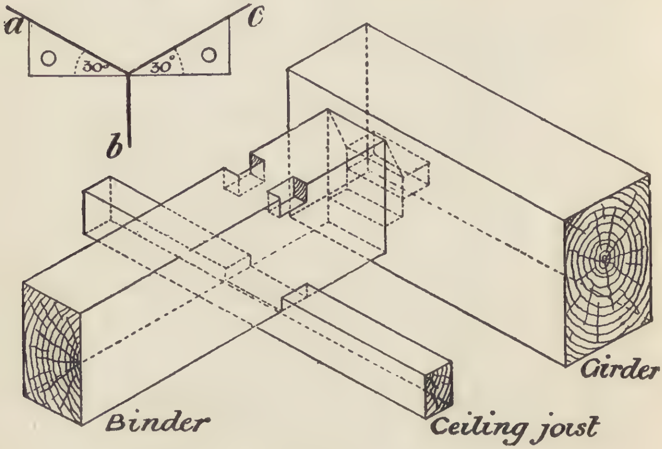


FIG. 4.

with binder, ceiling joist, etc. If the lines be carefully followed no difficulty will be found in adapting this system to many of the examples given in these pages.

CHAPTER II.

BRICKWORK.

8. General remarks.—Bricks for ordinary purposes are 9 inches long, $4\frac{1}{2}$ inches wide, and $2\frac{1}{2}$ inches deep. In good work the mortar joints should not exceed $\frac{3}{8}$ inch in thickness, otherwise the settlement in the wall may be excessive. In specifications it is generally stipulated that 'no four courses of brickwork must rise more than one inch beyond the height of the bricks laid dry.' Care should be taken to keep the courses horizontal and the face of the wall perpendicular. Every joint ought to be well filled with mortar, or **flushed up**, as it is termed. It is a common practice to pour into the joints of the bricks at every three or four courses, thin liquid mortar known

as **grout.** This is, however, objectionable. If the workmanship is good, there is no necessity for grouting.

In raising walls they should be carried up regularly, no portion being allowed to rise more than about three feet above the rest, otherwise a rupture is likely to occur between the older portion of the work and that last completed.

If one part of the brickwork is unavoidably delayed, each course should be left projecting beyond the one above it, thus forming a series of steps. This is termed **racking back**, and prevents the ill effects just mentioned, when the newer part of the wall is incorporated with it. In dry weather, bricks should be **thoroughly wetted** before being laid, to remove any dust which would prevent the perfect adhesion of the mortar, and also to ensure that the moisture contained in the mortar is not too rapidly absorbed.

The following terms used in this chapter require explanation :—

Headers.—These are bricks laid lengthwise across the thickness of the wall.

Stretchers.—This name is applied to bricks laid with their length parallel to the direction of the wall.

Heading courses are composed entirely of bricks laid as headers (fig. 5 and fig. 8A).

Stretching courses are made up of stretchers only (fig. 6 and fig. 8B).

Queen closers are formed by halving ordinary bricks longitudinally. In practice the bricks are generally first cut in two, crosswise.

King closers are bevelled bricks cut as shown at A (figs. 37 and 38).

Bats are broken bricks. They are designated $\frac{1}{2}$ or $\frac{3}{4}$ bats, according to size.

9. **Bond.**—This term refers to the arrangement of bricks or stones in a wall in such a manner as to prevent the occurrence of **continuous vertical joints.** On referring to fig. 7 it will be noticed the bricks have been so laid, that in no two adjacent courses are the joints vertically over one another.

By lapping the bricks as shown, the different portions of the

wall are well tied or bonded together, and the weight distributed over a larger number of bricks. There are several methods adopted of securing this interlocking or bond. Amongst others may be mentioned **heading, stretching, English,** and **Flemish** bonds.

Note.—The student should obtain a number of model bricks of wood, about $\frac{1}{3}$ the size of those in actual use. These will enable him to construct walls of various thicknesses, and practically illustrate the advantage of good bond. All the figures in this chapter should thus be reproduced with the models, care being taken to work in the bond as indicated.

Heading bond.—This consists entirely of courses of headers, and is used chiefly for turning sharp curves. If

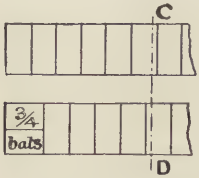


Fig. 5.

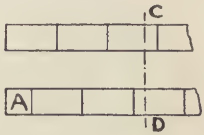


Fig. 6.

stretchers were used, their long edges would not conform so well to the curve of the wall, and its face would in consequence be rendered irregular.

Fig. 5 shows alternate courses of a wall constructed in this way, $\frac{3}{4}$ bats being used in every other course to prevent continuous vertical joints.

Stretching bond.—In this case the wall is built with stretchers only. Its chief use is for $\frac{1}{2}$ brick walls.

Fig. 6 illustrates alternate courses of this bond, the necessary lap being obtained by the use of a $\frac{1}{2}$ bat at A in every other course.

English bond consists of alternate courses of headers and stretchers.

The elevation and plans in figs. 7 and 8 will render the construction clear.

The insertion of a **queen closer** after the **first** brick in each heading course gives the necessary lap.

It should be noted that when English bond is used for walls equal in thickness to an **even** number of ½ bricks, the back and front elevations of any course will present the same appearance—i.e. any course showing headers on one side will also show headers on the other. With walls an **uneven** number of ½ bricks in thickness, each course will show headers on one side and stretchers on the other.

Fig. 8 shows plans of alternate courses of a wall 9 inches

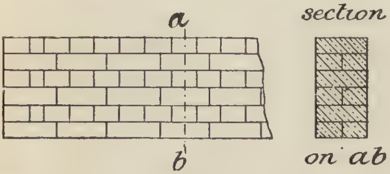


Fig. 7.

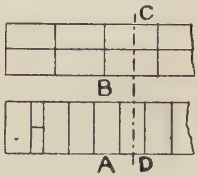


Fig. 8.

thick, built in English bond, while figs. 9, 10, and 11 furnish the same information as to walls 1½, 2, and 2½ bricks thick respectively.

In order to give a neat finish to the end of a wall, or

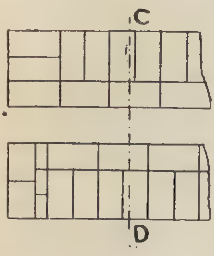


Fig. 9.

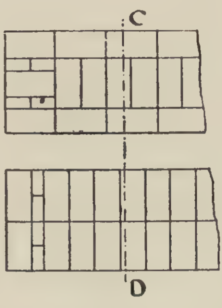


Fig. 10.

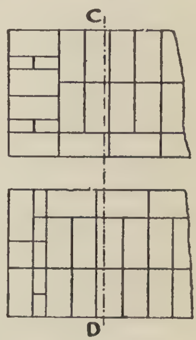


Fig. 11.

return, as it is called, the bond is slightly modified. Reference to the examples will render the method clear.

It will have been noticed that all the plans show continuous transverse and longitudinal joints. This is as it should be;

any attempt to alter it would lead to unbroken vertical joints in some parts of the work.

Flemish bond.—This method of bonding brickwork places headers and stretchers **alternately in every course,** as in fig. 12, closers being used in every other course for the same purpose as in English bond.

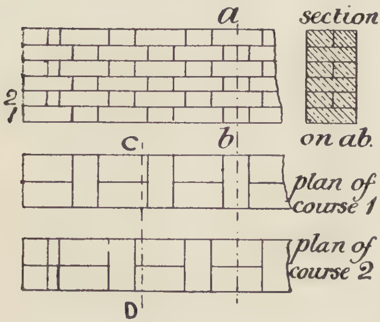
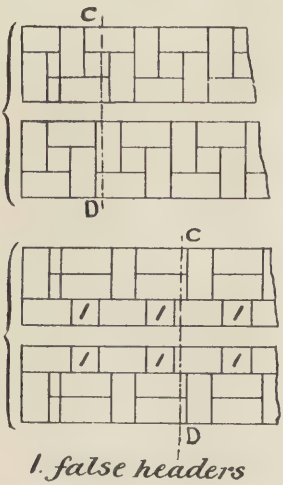


FIG. 12.

Flemish bond has a neater appearance than the preceding form, and is preferred for external walling, although on the whole it is inferior in strength to English bond. It will be seen on comparing the two that English bond has a **better transverse tie.** For the sake of appearance a **Flemish facing** is frequently added to a wall built in English bond.



FIGS. 13 and 14.

Double Flemish bond is

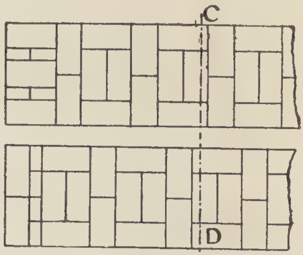


FIG. 15.

the term applied when the whole of the work, both front and back, is laid in Flemish bond, thereby presenting the same appearance on both faces. Figs. 13, 14, and 15 illustrate this. It should

be noticed that in fig. 13 all the headers are **whole bricks**, each assisting to bond the face and back with the interior of the wall. In fig. 14, however, half the headers in each course are replaced by ½ bats. It need scarcely be added that these **sham headers** are perfectly useless as ties. They are frequently inserted for economy's sake. This bond is termed **Double Flemish with false headers**. Fig. 15 shows the application of **Double Flemish bond** to a wall 18 inches thick, with returned end.

Single Flemish bond.—Reference has already been made to the use in a wall of **English bond backing** and **Flemish facing**. This is known as **Single Flemish bond**, and is illustrated in figs. 23 to 26 inclusive, the headers in alternate courses being false.

Angles or quoins of brick buildings.—Figs. 16, 17, 18, 19, 20, and 21 illustrate the mode of laying bricks in

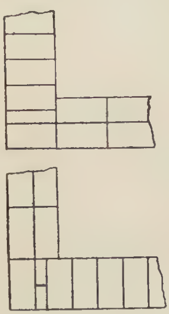


FIG. 16.

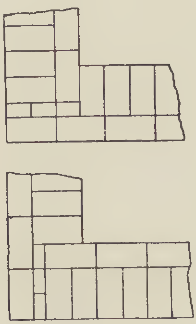


FIG. 17.

alternate courses at the junction of walls of various thicknesses built in English bond. In drawing these examples the best plan is to first put in the lines representing the longitudinal joints, afterwards inserting those running across the wall. The figures explain themselves and call for little remark.

In the last example, fig. 21, the queen closers are arranged differently, being carried quite through the thickness of the wall in a straight line, instead of being arranged stepwise as in the previous cases. This is the preferable construction, though

not so frequently used. The student will find, on working out these examples with the models, that this last method is the

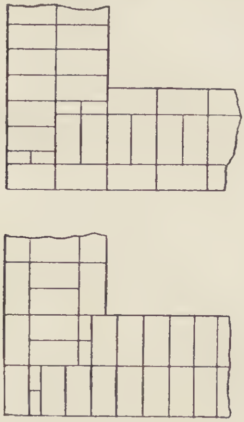


FIG. 18.

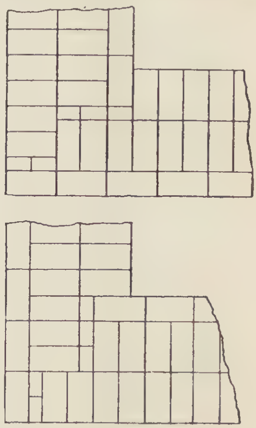


FIG. 19.

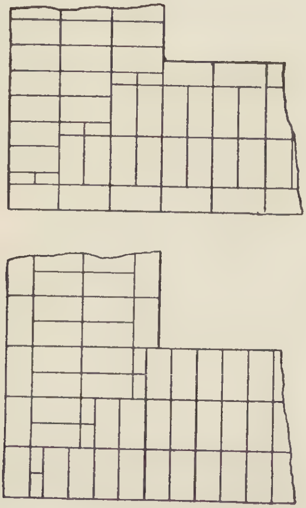


FIG. 20.

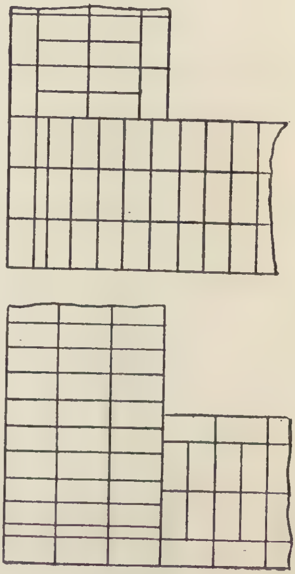


FIG. 21.

only one by which continuous vertical joints can be entirely avoided **in the interior** of the walling.

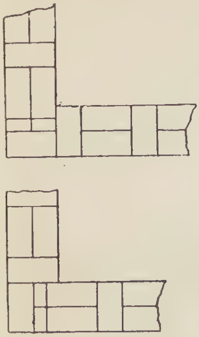
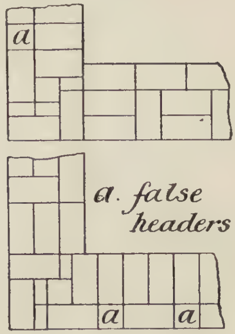


FIG. 22.



Figs. 22 to 26 inclusive show the plans of alternate courses of walls at right angles built in single Flemish bond, with the exception of the first case, where the walls, being only nine inches thick, must show Flemish bond on both sides.

The closers, instead of being inserted as indicated, may run in straight lines quite through the wall, as shown in fig. 21 for English bond.

Fig. 27 gives plans of alternate courses at the junction between a 14 inch main wall and a 9 inch party wall. The union of walls 1½ brick and 2 bricks thick respectively is illustrated in fig. 28.

By using ¾ bats at *a*, fig. 27, every alternate course of the 9 inch wall is bonded into the main wall.

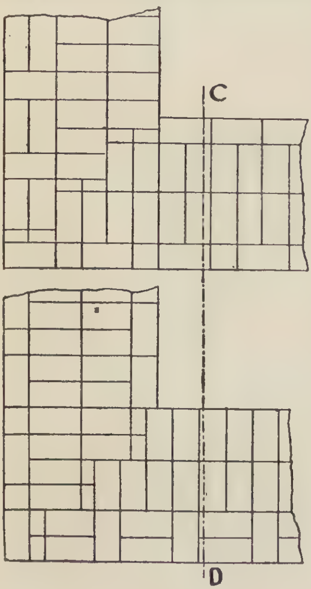


FIG. 24.

The intermediate courses of each, however, do not bond with each other.

In fig. 28 the use of queen closers at *a* is apparent.

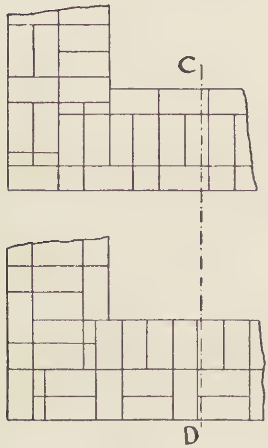


FIG. 25.

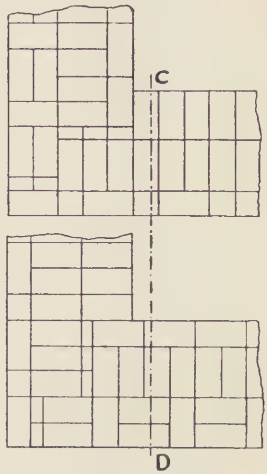


FIG. 26.

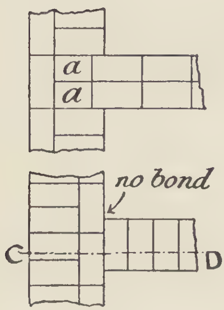


FIG. 27.

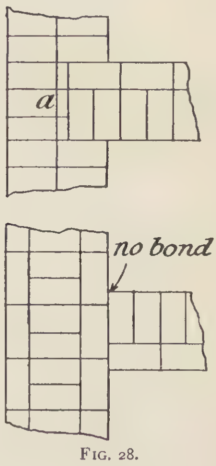


FIG. 28.

Garden bond.—This is used for walls 9 inches thick, and

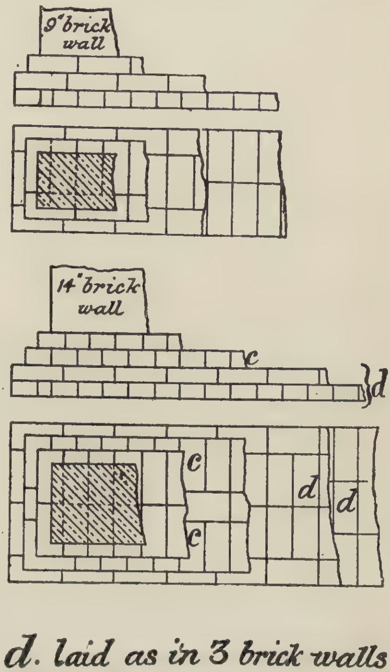
is termed English or Flemish according to the arrangement of the bricks.

English garden bond.—In this, the bricks of **one course** out of every **four** or **five** are laid as **headers**, the other courses consisting of stretchers. This bond is frequently used in domestic work on account of its very neat appearance.

Flemish garden bond contains headers and stretchers in **every row**; the former being inserted at intervals of about 3 feet.

Hoop iron bond.—Before leaving this part of the subject reference should be made to the very general use of **hoop iron** for the purpose of additional bond in brick walls. It may be about $1\frac{1}{2}$ inches wide and $\frac{1}{16}$ inch thick. Before use it must be well **tarred** and **sanded**. The usual practice is to insert it in parallel rows, one for each half brick the wall is in thickness at vertical intervals of 5 feet or thereabouts.

10. Footings.—The foundations of all walls should be spread out in steps so as to distribute the superincumbent weight over a larger area. These steps are termed **Footings**. See figs. 29 and 30.



FIGS. 29 and 30.

For light walls it will be sufficient if the footings are formed in **single courses** with the exception of lowermost, which should always be double. If, however, the weight to be borne is very great, then each

course must be a **double one.** The projection of each course beyond the one above should be $2\frac{1}{4}$ inches on each side of the walls until the bottom course attains a width equal to **twice the thickness of the wall itself.**

Thus a 9-inch wall will have a thickness of 18 inches at the base.

Where the footing courses are single, as in the illustrations, the bricks should if possible be laid as **headers on the outside,** in order to reach well into the interior of the wall. See fig. 30.

It need hardly be added that if the course is less than $2\frac{1}{2}$ bricks thick this rule cannot be adopted. Where double footing courses occur, they should be laid in the same manner as in an ordinary wall of like thickness. Before commencing the walls of a building it is usual to lay down a bed of **concrete** on which the footings may rest. This bed varies in thickness with the nature of the subsoil and the weight to be carried, but should never be less than 12 inches.

It must project on each side beyond the footings.

It is a good practice to **render in cement** the footings and wall itself up to the **ground line.** This helps to keep out the damp.

11. **Damp course.**—A damp course is used as a means of preventing moisture from rising in walls. The materials generally used for this purpose are **asphalte,** and **slates laid in cement.** If asphalte be used, it should be spread in a layer $\frac{1}{2}$ inch thick on the top of the brickwork as soon as it has risen about 12 inches above the ground line. Damp courses should be inserted immediately over the footings in basements.

When slates are used, two courses are inserted, carefully bedded and laid in floating cement, the upper course overlapping the joints in the lower. If this is not done, the slates are liable to crack from the superincumbent weight. They should project $1\frac{1}{2}$ inches beyond each side of the wall. Damp courses of glazed earthenware with openings for ventilation are now frequently adopted.

12. **Copings for brick walls.**—These may be of **stone** (see Chapter III.), **common brick, terra cotta, moulded brick,** etc.

Common brick copings are formed in various ways.

Fig. 31 shows a common arrangement known as a **brick on edge coping.**

The projecting course of bricks is sometimes replaced by a **creasing** formed with a double thickness of **tiles** or **slates,** fig. 32.

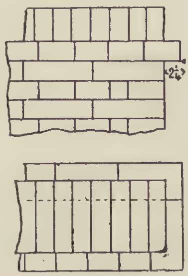


FIG. 31.

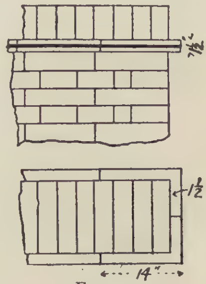


FIG. 32.

Fig. 33 gives the front and end elevations of a wall surmounted by a coping of bricks set at an angle of about 45°.

All brick copings should be set in **cement.** The projecting courses of bricks, tiles, or slates shown in the examples serve to throw off rain from the wall face. The copings mentioned above are greatly inferior in appearance and durability to those formed of **terra cotta, blue Staffordshire ware,** etc. The variety of shapes in which these purpose-made coping bricks can be obtained is very numerous. Fig. 34 shows three common forms.

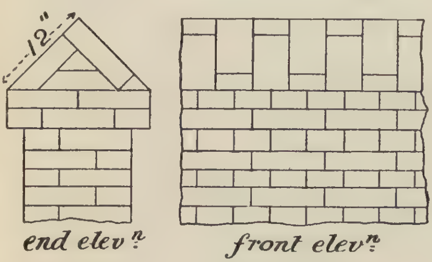


FIG. 33.

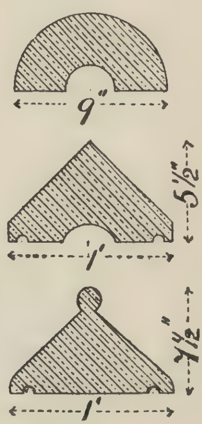


FIG. 34.

13. Brick corbelling.—This term refers to the projecting courses of brickwork built out from the face of a wall, in order to support a **wall plate, the end of a**

beam, etc., fig. 35. Several examples of its use will be found in the succeeding chapters. The amount of the projection of each course beyond the one below depends on the weight to be borne. It should never exceed $2\frac{1}{4}$ inches. In the illustration it is $1\frac{1}{8}$ inches.

14. Offsets.—These are **ledges** formed in a brick wall by suddenly **reducing its thickness,** fig. 36. On these ledges wall plates may be supported. This arrangement is very common in ground floors.

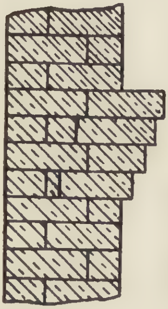


FIG. 35.

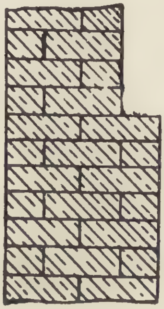
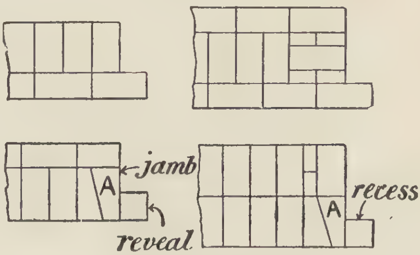


FIG. 36.

15. Openings in walls are left for the insertion of **doors** and **windows**. The top or **head** of the opening may be closed by an **arch, lintel,** or **bressummer.** The **sides** or **jambs** are sometimes square, at other times recessed, as in figs. 37 and 38, for the reception of a door or window frame.

The bottom of the opening is finished with a wood or stone **sill.**



FIGS. 37 and 38.

16. Jambs.—When left square, these may be finished off in the same way as the returned ends of the walls in figs. 9, 10, 11, etc.

If recessed, the bond must be slightly modified. The disposition of the bricks for $1\frac{1}{2}$ and 2 brick walls built in English bond is shown in figs. 37 and 38. The term **reveal** is given to the brickwork in front of the space left for the framework. This space is termed **a recess.**

17. **Sills** for window openings are usually of stone, weathered or dressed to a slope on the upper surface in order to prevent water standing there, and having a **groove** or **throat** cut along the underside of the portion which projects beyond the wall. This is done to intercept any water which may find its way under the bottom edge of the sill. See fig. 40.

When a stone sill is built in during the progress of the brickwork, as is usually the case, a space of about $\frac{3}{8}$ inch should be left beneath the intermediate portion, so that it has a bearing at the ends only.

Owing to the weight of the brickwork of the jambs, the settlement in the wall is greater at the ends of the sill than under the middle.

It will be easily seen that if at first the sill were firmly bedded at the centre, the weight at the ends being supported by the sill only, owing to the settlement of the brickwork, would fracture it. **External door sills** are generally of **stone** or **oak.**

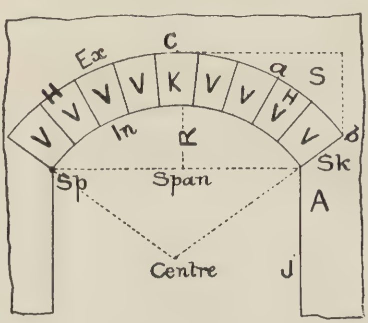


FIG. 39.

18. **Arches.**—A reference to fig. 39 will explain the meaning of the following terms, used in connection with arches :—

Extrados or Back	Ex.
Intrados or Soffit	In.
Voussoirs	V.
Key	K.
Crown	C.
Haunch	H (from *a* to *b*).
Skewback	the line Sk.
Span	Span.
Springing	Sp.
Centre	Centre.
Rise	R.
Abutment	A.
Spandril	S (space within the dotted lines).
Jamb	J.

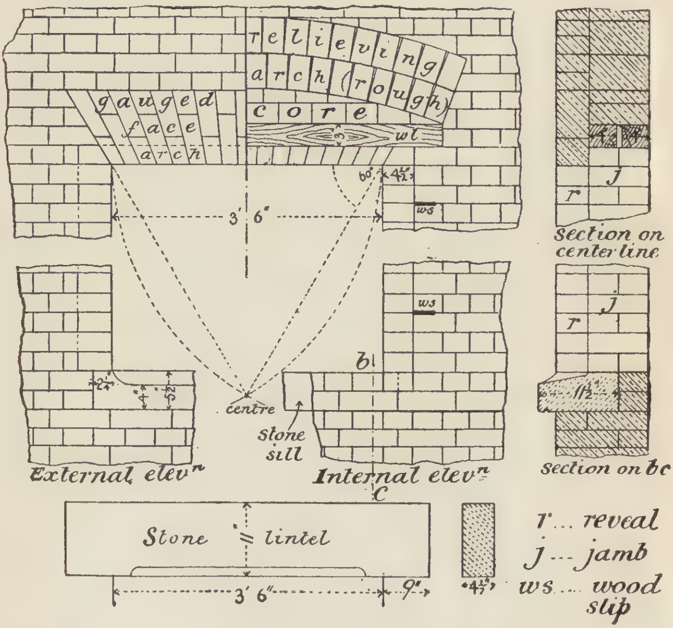


FIG. 40.

Rough brick arches are formed with uncut bricks. Consequently the joints are wider at the back of the arch than at the soffit.

An example of this kind of arch is given in fig. 40. Two half brick rings are shown, in place of one 9 inches thick. The width of the joints at the extrados is by this means diminished. Compare the joints in this arch with those shown in fig. 41.

The bricks in a rough arch being uncut, have their sides parallel. Therefore, when drawing its elevation, in order to preserve this parallelism the lines representing the joints should not converge to a point, but must be drawn as **tangents to a circle** at the centre of the arch, having a diameter equal to the thickness of a brick, i.e. $2\frac{1}{2}$ inches. Fig. 41 explains this.

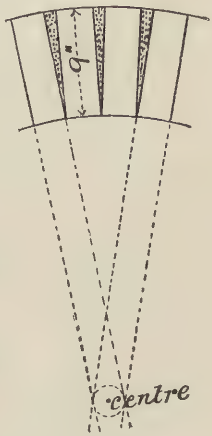


Fig. 41.

Axed or rough-cut arches.—In these the bricks are roughly chipped with an axe to the required wedge shape. They are generally used when the wall has to be finished with a coat of plaster

Gauged arches are constructed of specially made soft bricks termed **cutters** or **rubbers.**

These are first cut **approximately,** and afterwards rubbed **accurately** to the necessary shape. By this means very fine joints are obtained. Gauged work is often set in **putty** (a material formed by dissolving pure lime in water) instead of mortar.

Face arches are those showing on the face of a wall for the sake of ornament, and therefore built in gauged work.

They may be **flat, segmental, semicircular, French or Dutch, elliptical,** etc.

Flat arch.—This is illustrated by the external elevation given in fig. 40.

The centre to which all the voussoirs converge is the **apex of an equilateral triangle** described on the soffit of the arch.

A rise or **camber** of $\frac{1}{8}$ of an inch per foot of span is usually allowed when constructing a flat arch to allow for settlement in the work.

A section through the centre line of this face arch (fig. 40) shows that it extends only $4\frac{1}{2}$ inches into the thickness of the wall.

It therefore does very little towards supporting the weight of the wall above. This may be carried by a **relieving arch** at the back of the wall, as indicated, **or a rolled** iron joist, the latter resting on a stone template on each side of the opening. A **wood lintel** is placed across below the relieving arch, the space between the former and latter being filled in with bricks. This portion is known as the **core.**

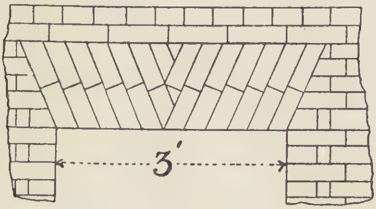


FIG. 42.

The wood lintel is used for the purpose of affixing a door or window frame.

French or Dutch arch. — Although so termed, this construction lacks the leading principle of the arch. An examination of the figure will show that the members of which it is composed (in this case bricks) are not wedge shaped. This arch is very faulty in design ; it should never be used.

Stone lintels are often substituted for flat gauged arches, fig. 40.

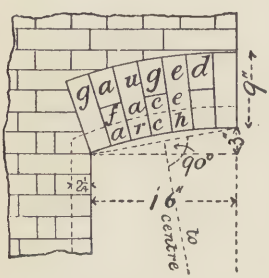


FIG. 43.

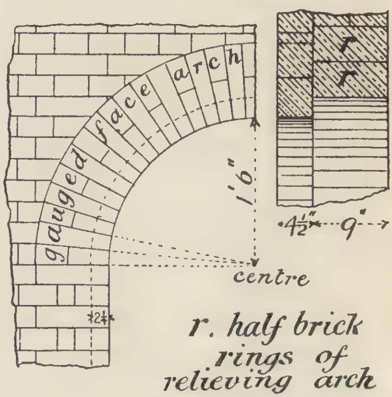


FIG. 44.

Segmental arch.—This is given in fig. 43, which shows the method of finding the centre, having given the **span** and **rise.**

Semicircular arch.—Fig. 44 is a half elevation and

section of an arch of this description, with a relieving arch turned in half-brick rings.

Pointed arch.—The method of obtaining the proportions of one form of this arch is given in fig. 44 *a*. The curves are struck from the ends of the base of an equilateral triangle, with a radius equal to the base. For a description of various other styles of arch, the student should consult any good work on architecture.

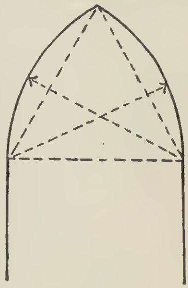


Fig. 44 *a*.

19. Securing timber to brickwork.

—For the purpose of fixing woodwork to walls, **wooden blocks** equal in thickness to a brick and two mortar joints may be built in at the points required. **Wood slips** about $\frac{3}{8}$ of an inch thick are now more often employed. They are built into the joints of the wall where necessary, and are less liable to become loose by shrinking.

Wood plugs about 5 inches long are sometimes driven into the joints of brickwork and masonry. To these plugs the woodwork may be nailed.

When used in this way, the bricks and stones are often displaced and the work seriously shaken. A better plan is to insert them in holes cut in the brick or stone itself.

No wood plugs should be used near flues.

Material bricks.—These are built into the wall in the place of ordinary bricks, and are sufficiently soft to allow of nails being driven into them. One great advantage arising from their use is that, unlike wood, no shrinkage can ever occur to loosen them, as is so frequently the case when the latter material is employed.

The composition of material bricks may be—

Breeze	6 parts.
Portland cement . .	1 part.

Exercises on Chapter II.

Note. The figures given in Chapter II. not mentioned in the following exercises should all be drawn to a scale of 1″ to 1′.

1. Draw to a scale of $\frac{1}{12}$, figures 5, 6, 8, 9, 10, and 11, adding in each

case an elevation of six courses of the brickwork, an elevation of the returned end, and a section on the line C D.

2. Show a section to a scale of 1″ to 1′ on the line C D, fig. 12.

3. Draw figs. 13, 14, and 15 to a scale of $\frac{1}{12}$, adding sections on the lines C D.

4. Draw figs. 16 to 23 inclusive to a scale of $\frac{1}{12}$. Give in each case an isometric projection of the angle.

5. Draw figs. 24, 25, 26, and 27, and show sections on the line C D. Scale $\frac{1}{12}$.

6. Show about 6′ in length of a dwarf brick wall, 4′ high and 9″ thick, surmounted by one of the moulded brick copings illustrated in fig. 34. Front elevation and section to be given. Scale $\frac{1}{12}$.

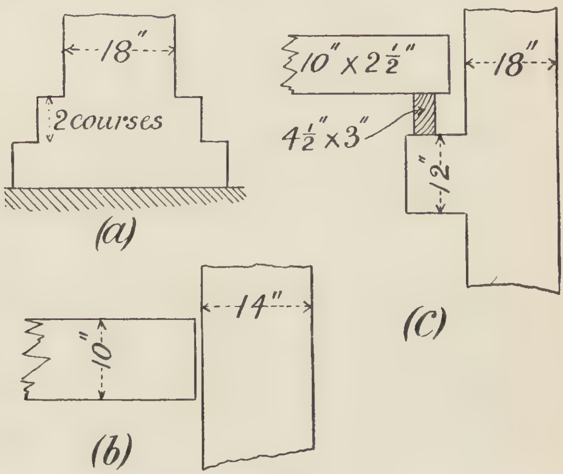


FIG. 45.

7. Wall plates $4\frac{1}{2}''$ × $3''$ are to be supported (1) by corbelling out an 18″ brick wall, (2) by an offset in a $2\frac{1}{2}$ brick wall. Show a section of each with the plates in position. Scale $1\frac{1}{2}''$ to 1 .

8. Draw figs. 37 and 38 to a scale of $\frac{1}{12}$, and give an elevation of about eight courses of the jambs.

9. Give complete outside and inside elevations of the window opening shown in fig. 40, replacing the gauged face arch with a stone lintel. Height of opening 6′ measured from the underside of the lintel to the top of the stone window sill. Give also a section through the centre of the opening, showing an 18″ wall, 9″ reveal, and 12″ × 6″ stone sill.

10. Draw to a scale of $\frac{1}{4}$, figs. 43 and 44, showing the face arches complete.

11. Section of a wall 2 bricks thick with footings, fig. 45 (*a*). Draw to a scale of 1″ to 1′ and show the joints (by single lines); English bond.

12. Section through a 14″ brick wall, built in English bond, showing the end of a floor joist which is to rest on a $4\frac{1}{2}'' \times 3''$ plate carried on brick corbelling, fig. 45 (*b*). Draw to a scale of $\frac{3}{4}''$ to 1′, adding the wall plate and brick corbelling, and showing the joints of the brickwork by single lines.

13. Section through a wall built in English bond, showing the end of a floor joist supported by corbelling out the brickwork, fig. 45 (*c*). Draw

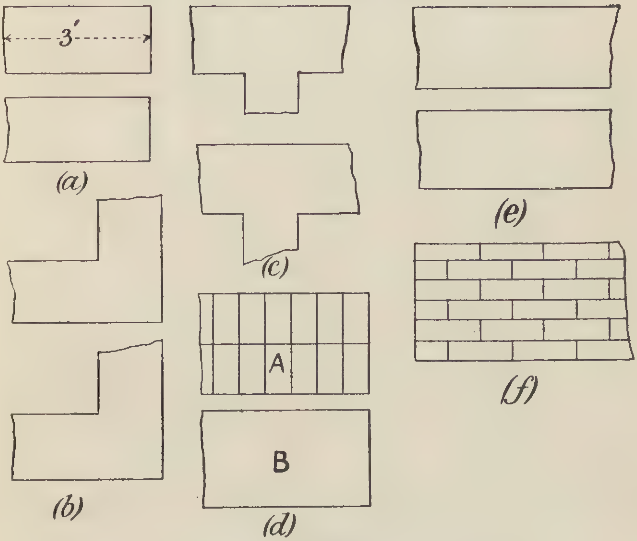


FIG. 46.

to a scale of $\frac{1}{12}$, making any corrections you may consider necessary, and showing by single lines the joints of the brickwork.

14. Plan of two successive courses at the end of a 14″ brick wall built in Flemish bond, fig. 46 (*a*). Draw to a scale of $\frac{3}{4}''$ to a foot, showing the joints of the brickwork by single lines.

15. Plan of two successive courses of brickwork at the angle of a $2\frac{1}{2}$ brick wall, fig. 46 (*b*). Draw to a scale of 1″ to a foot, showing the bricks arranged in English bond with Flemish bond on outer face.

16. Plans of two successive courses of brickwork, showing the junction of a $1\frac{1}{2}$ brick party wall with a $2\frac{1}{2}$ brick main wall, fig. 46 (*c*). Draw to a scale of $\frac{3}{4}''$ to a foot, showing the bricks laid in English bond.

17. A and B are plans of two courses of bricks at the end of a wall, fig.

46 (*d*). Draw both courses to a scale of $\frac{1}{12}$, altering A if necessary and showing on B the joints of the bricks by single lines. Give the name of the bond.

18. Plan of part of a brick wall 3 bricks thick, fig. 46 (*e*). Draw to a scale of 1″ to a foot the plan of two successive courses, showing the arrangement of the bricks in each course, in English bond. The drawings of the two courses to be one above the other, as shown in the figure.

19. Elevation of 6 courses at the end of a 14″ brick wall built in old

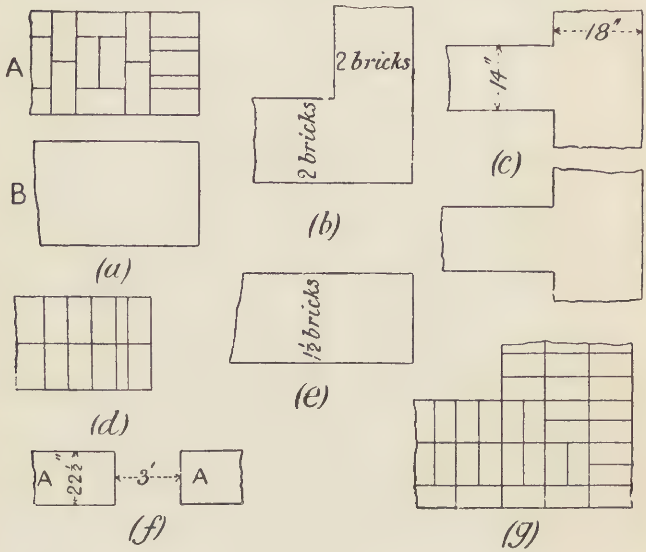


FIG. 47.

English bond, fig. 46 (*f*). Draw to a scale of 1″ to 1′, making any alteration you may consider necessary.

20. Plan of two successive courses at the end of a brick wall, fig. 47 (*a*). Draw to a scale of 1″ to 1′, writing the name of the bond against A, and filling in B with the joints of the brickwork so as to break bond with A.

21. Plan of the angle of a brick building, walls 2 bricks thick, fig 47 (*b*). Draw to a scale of 1″ to 1′ the plan of two successive courses, showing the arrangement of the bricks in each course in English bond.

22. Plan of two successive courses of brickwork, where a party wall joins the main wall of a building, fig. 47 (*c*). Draw to a scale of $\frac{3}{4}$″ to a

foot, showing the arrangement of the bricks in each course, the party wall being in English bond, and the main wall in single Flemish bond.

23. Plan of a course of bricks at the end of a 2 brick wall, fig. 47 (*d*). Draw to a scale of $\frac{1}{12}$ the plan of the next course and write against it the name of the bond.

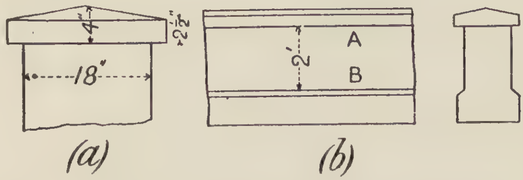


FIG. 48.

24. Plan of the end of a brick wall $1\frac{1}{2}$ bricks thick, fig. 47 (*e*). Draw to a scale of 1' to a foot the plan of two successive courses, showing the arrangement of the bricks in each course in English bond.

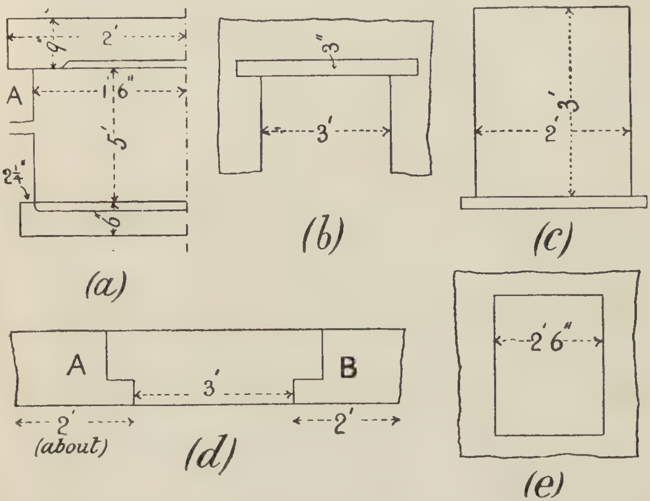


FIG. 49.

25. Explain the meaning of English bond in brickwork. In fig. 47 (*f*) A and A are plans of two successive courses of bricks on either side of an opening in a $2\frac{1}{2}$ brick wall. Draw to a scale of 1" to 1', showing the joints of the brickwork by single lines.

26. Plan of a course of brickwork at the angle of a building, fig. 47 (*g*).

Draw to a scale of $\frac{3}{4}''$ to a foot, inserting closers and giving the name of the bond.

27. Part of the end elevation of a brick wall with a stone coping, fig. 48 (*a*). Draw to a scale of $1''$ to 1 brick showing the joints of the brick-work by single lines.

28. Elevation and section of part of a dwarf brick wall, fig. 48 (*b*). Draw the elevation to a scale of $\frac{1}{12}$, showing four courses of English bond at A and four courses of Flemish at B.

29. Elevation of half a window opening in a brick wall built in English bond, fig. 49 (*a*). Draw to a scale of $\frac{3}{4}$ of an inch to a foot, showing the joints of the brickwork at A by single lines.

30. Part of the elevation of the head of an internal doorway with a wood lintel above, fig. 49 (*b*). Draw to a scale of $1''$ to a foot, adding a common brick discharging arch, turned in two rings. The joints of the arch to be shown on about half the face of the arch.

31. Inside elevation of a small window opening, fig. 49 (*c*). Draw to

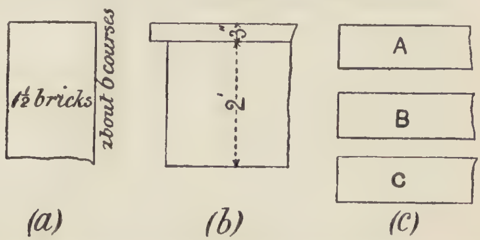


Fig. 50.

a scale of $1\frac{1}{2}''$ to $1'$, showing a $3''$ wood lintel with a common brick dis-charging arch above in two rings. No joints to be shown except those of the arch.

32. Horizontal section through a window opening, with reveals and square jambs, fig. 49 (*d*). Draw to a scale of $1''$ to a foot and fill in at A and B two successive courses (i.e. one course at A, the other at B), showing the arrangement of the bricks in each course, the wall of the building being in English bond.

33. Inside elevation of a window opening in a brick wall, fig. 49 (*e*). Draw the head of the window to scale of $1\frac{1}{2}''$ to a foot, showing a wood lintel $4'$ long by $3''$ deep, with a discharging arch in two rings above it. The separate bricks of the ring need not be shown.

34. Section of the top of a boundary wall $1\frac{1}{2}$ bricks thick fig. 50 (*a*). Draw to a scale of $1''$ to $1'$ and add a stone coping $4''$ thick, weathered and throated.

35. Elevation of the end of a dwarf brick wall, built in Flemish bond with a flat coping stone, fig. 50 (*a*). Draw to a scale of $1''$ to a foot, showing the joints of the bricks by single lines.

36. A, B, and C each represents in plan a course of bricks at the end of a $1\frac{1}{2}$ brick wall, fig. 50 (*c*). Draw them to a scale of $\frac{1}{12}$, showing on A the bricks arranged in English bond with Flemish face, on B, Flemish bond without any false headers, and on C, Flemish bond with bats used as false headers in order to economise the facing bricks.

37. Elevation of the head of a door opening filled in with a common flat arch used in inferior work and known as a French or Dutch arch, fig.

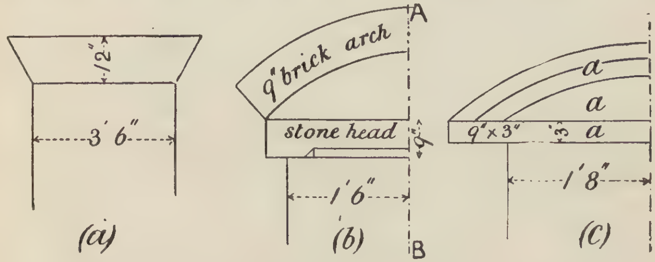


FIG. 51.

51 (*a*). Draw to a scale of $\frac{1}{12}$, showing by single lines the joints of the bricks forming the arch.

38. Elevation of a window head in an 18" brick wall with 9" reveals, fig. 51 (*b*). Give a vertical section through A B, showing all the details of construction before fixing the window frame. Scale $\frac{3}{4}$" to 1'.

39. Elevation of the head of a door opening in a brick partition wall, fig. 51 (*c*). Draw to a scale of $\frac{1}{30}$, making any correction you may con-

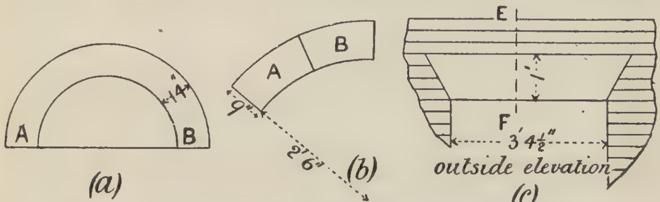


FIG. 52.

sider necessary, write the names of the parts marked *a*. The joints of the wall not to be shown.

40. A semicircular opening in a brick wall, fig. 52 (*a*). Draw to a scale of $1\frac{1}{2}$" to a foot, showing at A six courses of a plain or rough arch, and at B four courses of an axed or rough cut arch.

41. Half a segmental brick arch, fig. 52 (*b*). Draw to a scale of 1" to a foot, showing a plain or rough arch at A, and an axed or rough cut arch at B.

42. Outside elevation of a gauged brick camber arch over window opening (4 courses of brickwork to 1 foot in height), fig. 52 (*c*). Draw to a scale of $\frac{3}{4}''$ to one foot. Fill in the joints of the brickwork both in the arch and wall in Flemish bond. Also give a section through E F in an 18″ wall on the same scale.

43. Plan and elevation of a door opening in the internal wall of a house showing lintel, fig. 53 (*a*). Draw to a scale of $\frac{3}{4}''$ to 1′, add on elevation the discharging arch of two half brick rings, and show plugging or wood bricks for fixing joiner's work.

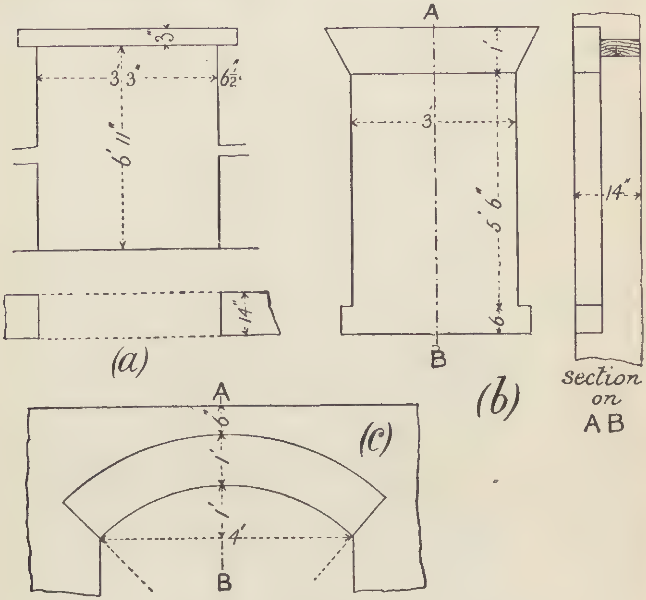


FIG. 53.

44. Outside elevation and section of a window opening in a 14″ brick wall with $4\frac{1}{2}''$ reveal, fig. 53 (*b*). Draw to scale of $\frac{1}{12}$, and add stone window-sill 10″ × 6″, sunk, weathered, and throated, with stopped ends.

45. Outside elevation of a segmental gauged brick arch over a window opening (four courses of brickwork to one foot in height), with part of wall, fig. 53 (*c*). Draw and fill in the joints of the brickwork on half the drawing, both on arch and wall, the wall being in English bond. Give a section on A B, the wall being 2 bricks thick, and show wood bricks or plugs for fixing joiner's work. The scale to be $\frac{1}{24}$.

CHAPTER III.

STONEWORK.

20. **General remarks.**—The stonemason, unlike the bricklayer, deals with a material which comes to his hands in **irregular shapes** and **of all sizes.** It is a much more difficult matter to construct a wall of stone, having due regard to perfect bond, than it is to erect one with bricks.

One of the chief points requiring attention is, that with the exception of a few cases every block of stone should be laid with its natural bed perpendicular to the direction of the pressure sustained. By the term **natural bed** is meant that surface on which it rested before being quarried. This rule does not apply in the case of **cornices** and other overhanging portions. In these the layers or strata of which the stone is composed should be **vertical**, and perpendicular to the face of the work.

A moment's consideration will show that in the latter cases the laminæ, if horizontal, would flake off, being unsupported below. Stone is dressed or worked in various ways according to the purpose for which it is intended.

At the quarry, a block of stone, after being detached from the rock, is roughly squared up by means of the axe or hammer. When thus brought into shape it is styled hammer dressed.

If the surfaces are required to be more truly plane, a **chisel draft** is sunk round the margin of each, and also diagonally from corner to corner (fig. 54).

FIG. 54.

These draughts are worked so as to be in the same plane. The intermediate portions are then brought down to a level with them.

For certain classes of work requiring a smooth surface the marks left by the chisel are removed by rubbing with a slab of stone and fine sand.

21. Joints and connections for stonework.—Great care should be taken in cut stonework that the bed joints are not dressed truly plane **for a few inches only** from the face. In order to obtain fine close face joints without the labour of accurately dressing the whole bed, the tail portion of the joint is often worked hollow (fig. 55).

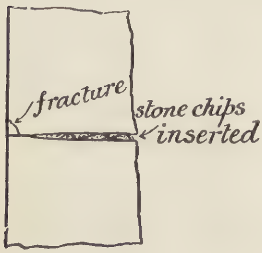


FIG. 55.

Small pieces of stone are inserted as shown to bring the face perpendicular.

This is termed **underpinning,** and frequently leads to rupture at the front edge of the block.

The stones should be in actual contact with each other from **face to tail.**

Piers and other parts subjected to pressure should not have too close joints, or the stone will be sure to flash, i.e. fracture at the edges.

Sheet lead is frequently inserted between the joints of heavy columns. This yields to any inequalities in the stone, and thus assists in distributing the pressure.

In erecting the inferior kinds of stone walling presently to be described it should be borne in mind that the source of strength lies in the **stone,** not in the **mortar.** The joints should therefore be as fine as possible. In laying masonry, the surfaces of all stone should be **thoroughly wetted** before being placed in position.

The same remark was made in Chapter II. with respect to brickwork, and the explanation there given holds good in the present case.

22. Metal cramps.—These are preferably of **copper** or **bronze. Iron** is, however, generally used, owing to its cheapness. One great objection to this metal is its liability to oxidation. The formation of rust causes an increase in volume, which frequently splits the stones in which the cramp is used. This rust also causes **discoloration** in the work. The ill effects just referred to may be avoided if the iron be **thoroughly**

galvanised or covered with a coating of some moisture-resisting material.

Fig. 56 shows a plan and sectional elevation of a joint between two stones, secured by a **metal cramp** 12 inches long, $1\frac{3}{4}$ inches wide, and $\frac{1}{2}$ inch thick, the ends being **jagged** and turned down $1\frac{1}{2}$ inches. A groove the width of the cramp, and $\frac{3}{4}$ of an inch deep, is first cut in the stone. At each end of this groove a hole, **dovetail in section,** is sunk. The cramp being placed in position as indicated, the channel may be filled with **molten lead, cement,** or a mixture of **melted sulphur and sand.** The cramp is thus protected from the weather. Of the three materials mentioned, lead is the least preferable. It contracts on cooling, and consequently becomes loose in its socket, necessitating the process of caulking. This consists in **burring up** the metal, when cold, with a chisel. In some positions this operation is highly inconvenient, if not impossible. However well it may fill up the space, there is no adhesion between the lead and the stone. For these reasons it should not be adopted as a filling-in material. There is in addition a galvanic action set up between the two metals iron

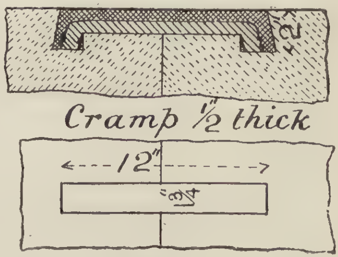


Fig. 56.

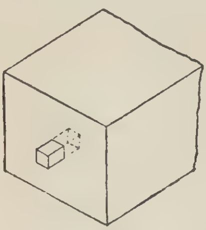


Fig. 57.

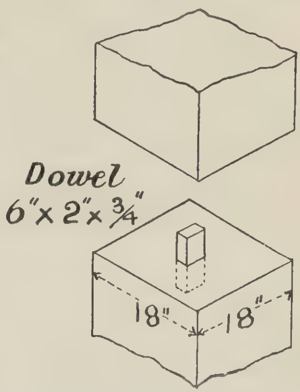


Fig. 58.

and lead, which rapidly corrodes the former. The use of cement and sulphur is not open to any of these objections. These may with advantage be mixed with a small proportion of **sharp sand** or **stone dust.**

23. **Dowels.**—Dowels are pins of **metal, hard stone, slate,** or **cement**, used to prevent lateral motion between one stone and another.

Their use in horizontal and perpendicular positions is shown in figs. 57 and 58. In the first of these the dowel is of slate and square in section, one half its length projecting into each stone. In practice the dowel is made to fit loosely in its socket and afterwards run with **lead, cement, sulphur,** or **plaster of Paris**. The better plan, however, is to secure an accurate fit, the dowel being made tapering at one end to assist in this.

When, as in fig. 58, the dowel is used at a bed joint, it is known as a **bed plug.**

An instance of its use in this position occurs in the method sometimes adopted of preventing the coping stones of a gable

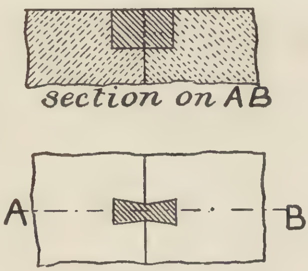


FIG. 59.

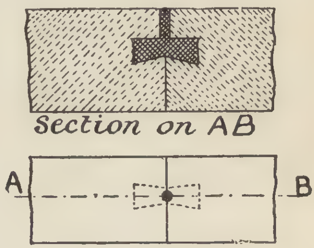


FIG. 60.

sliding down the incline. Plugs of York stone about 11 inches long and 3 inches square are built into the brickwork at the top of the wall so as to project about $1\frac{1}{2}$ inches.

The projecting portions fit into mortises cut in the coping stones, and are secured with cement.

Fig. 59 is an example of a horizontal dowel, dovetail in plan, and dropped into position from the top of the stone.

The dowel or plug illustrated in fig. 60 is of lead. The

holes in the stones to be connected are dovetail in plan and elevation. A small channel cut from them to the surface enables the lead to be run in so as to fill up the cavity.

24. Joggle joints.—Figs. 61, 62, 63, and 64 are forms of joggle joints used by masons for various purposes.

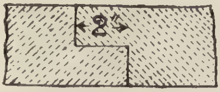


Fig. 61.

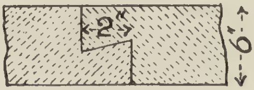


Fig. 62.

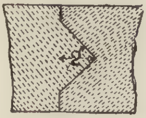


Fig. 63.

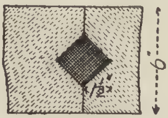


Fig. 64.

The coping stones shown in fig. 75 are united by the joggle joint shown in fig. 61. Fig. 63 gives a very common joint for stone landings. A triangular tongue is cut on the edge of one flagstone, fitting into a corresponding groove worked in the edge of the other.

A more economical method, and one of growing use, is to make a groove in both edges and fill the space formed by bringing them together with **Portland cement.**

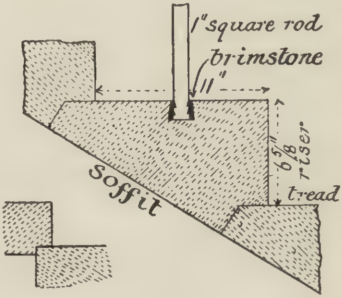


Fig. 65.

25. Stone steps.—The steps of stone staircases are usually blocks of stone either rectangular in section or worked so that the soffit is an inclined plane. Two methods of forming the joint between the steps are given.

The iron standard for carrying a handrail is also shown let into the step and run with brimstone. Stone steps are in some cases supported by walls at both ends. Not less than 6 inches of the steps must be built into each wall. If fixed at one end

only (hanging steps), 9 inches should be securely built into the wall.

26. Stone walls.—In building stone walls it is of the utmost importance to secure good bond. The terms **header** and **stretcher** are used in masonry with the same ideas as in brickwork.

Headers should in all cases extend into the wall $\frac{2}{3}$ of its thickness, and from opposite sides, while here and there a stone known as a **bonder** or **through stone** should be laid quite through from front to back.

The **through stones** of one course must come over the **middle of the spaces** between those of the course immediately below.

The vertical joints of one course are not to be less than 4 inches on one side of those in the next course, and the headers should rest as nearly as possible on the middle of the stretchers in the course below. Stone walls are said to be built in—

(1) **Rubble,** when the stones are only roughly hewn into shape ;

(2) **Ashlar,** when constructed of stone carefully dressed to show fine joints.

Rubble masonry is classified as follows :—

(1) **Random rubble uncoursed ;**

(2) **Random rubble coursed ;**

(3) **Squared rubble uncoursed,** or **irregular snecked rubble ;**

(4) **Squared rubble coursed ;**

(5) **Regular coursed rubble.**

Random rubble (uncoursed).—The stones used for this work are of all shapes and sizes. Fig. 66 gives an elevation and section of a wall built in uncoursed rubble.

No attempt is made to dress the stone into any particular form, beyond chipping off corners and projections with a hammer. The spaces between the stones are filled with chips or spalls, and well flushed up with mortar. Great care and skill are required in laying the stones in order that, by interlocking them, good bond may be obtained. Long vertical joints both

on the face and in the centre of the wall are to be avoided. The strength of this kind of masonry, when subjected to vertical pressure, is not much greater than that of the mortar used. Bonders should be used in all the courses.

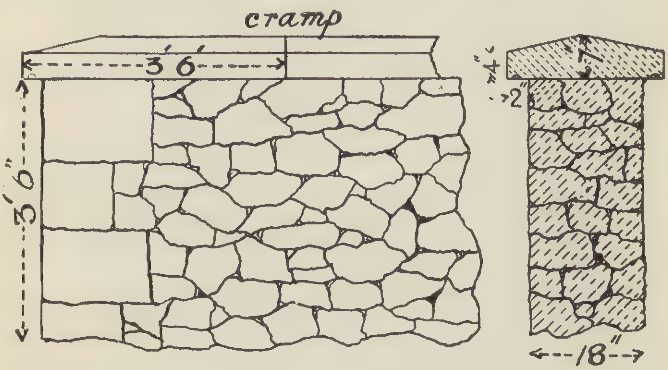


FIG. 66.

Random rubble (coursed).—In this kind of walling the work, although built of the same material as the former, is

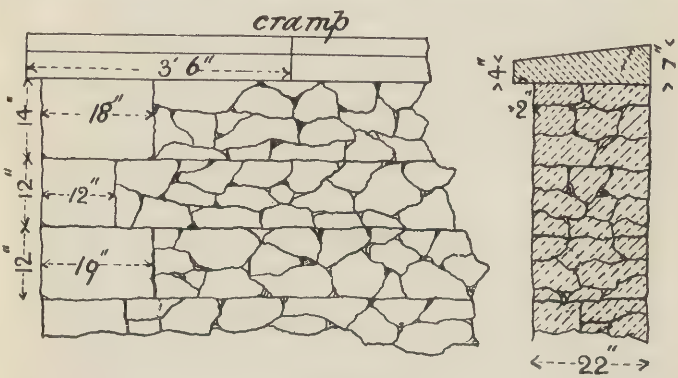


FIG. 67.

levelled at heights of from 9 to 15 inches, so as to present the appearance shown in fig. 67.

Fig. 68 illustrates in section a coursed rubble wall, lined on the inside with brickwork. In order to obtain a good bond

between the stone facing and brick lining, the latter is alternately $4\frac{1}{2}$ inches and 9 inches in thickness.

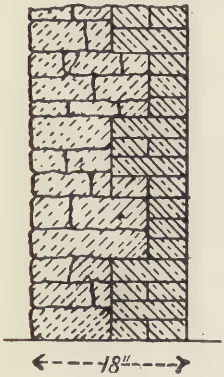


Fig. 68.

Squared rubble (uncoursed), fig. 69.—The stones for this are of all sizes, but worked so as to show horizontal and vertical joints. Large blocks are introduced here and there to assist in obtaining bond.

Squared rubble (coursed), fig. 70.—The stones are prepared as in the previous case, but each course is levelled at heights of about 12 or 13 inches.

Regular coursed rubble is shown in fig. 71. It will be noticed that the stones are roughly dressed into shape, and are of the same height throughout each course. The heights of the courses, however, vary from 3 to 8 inches, or thereabouts.

Note.—The thickness of the walling in figs. 69, 70, and 71 is 22 inches.

Block in course.—This is a class of masonry interme-

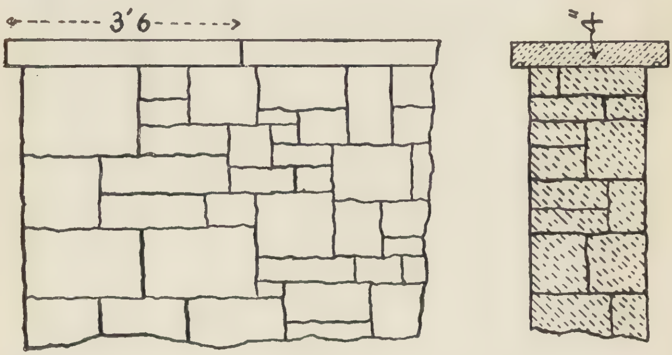


Fig. 69.

diate between rubble work and ashlar. It is not much used for ordinary buildings, but is largely employed by engineers.

The stones are roughly dressed, so that the beds and vertical joints are approximately horizontal and vertical. The different courses are not necessarily of the same height, but may vary from 8 to 14 inches, or thereabouts.

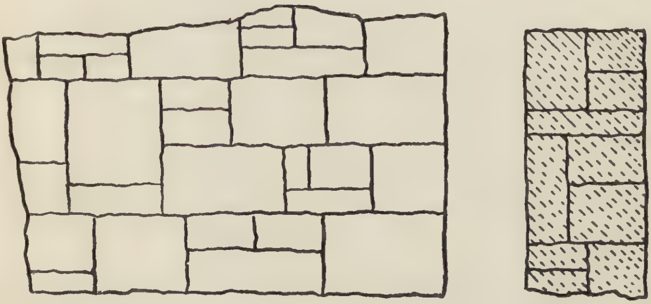


FIG. 70.

Ashlar.—In the most expensive walls the masonry is of cut stone, carefully dressed so as to show fine joints. This class of work is stronger and more solid than any other, the

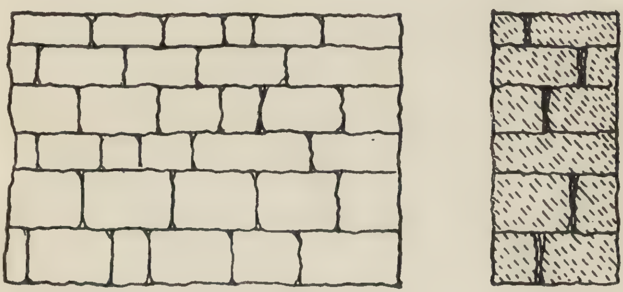


FIG. 71.

strength depending on (1) the size of the blocks of stone used, (2) the accuracy of the dressing, and (3) the mode of bonding employed.

With respect to the first of these no fixed rule can be laid down. It has, however, been given on good authority that

with ordinary stone the breadth should be at least equal to the thickness, and the length three times the thickness. When the breadth and length exceed these dimensions there is considerable danger of fracture if subjected to unequal pressure. No stone should be less than 9 inches deep.

Ashlar work may be classified as **regular** and **irregular coursed.** In the former, the courses are of equal, and in the latter of unequal heights, which generally vary from 11 to 18 inches. The face of each stone is for most purposes worked smooth. In some cases, however, it is left in the rough state known as rock faced, a drafted margin $1\frac{1}{2}$ inches wide being frequently sunk round the edges (see fig. 72) for the purpose of

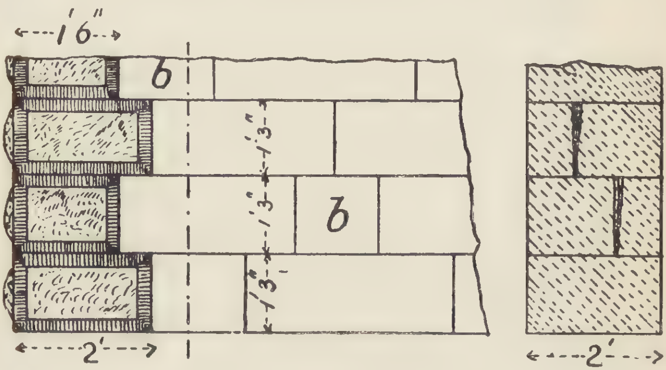


FIG. 72.

ornament, and also to assist in accurately setting the stones. It is usual to lay the blocks as headers and stretchers alternately, as in Flemish bond for brickwork. In the very best work the stones are cut to the same length, so that the joints of alternate courses may be vertically over one another. Though giving a regular appearance, this is neither usual nor necessary.

In irregular coursed ashlar the heavier blocks are placed below.

Ashlar facing.—The great expense of ashlar work has led to the practice of having the face only of cut stone, with a backing of brick or inferior masonry.

This, however, is open to one great objection ; the number

of mortar joints in the backing being larger than that in the facing, the settlement is unequal. By setting the bricks or stones of the backing with very thin joints, this drawback may be partially overcome.

Ashlar facing stones may be about 2 feet 6 inches long, 12 inches high, and 8 inches thick. To secure a bond between the front and back, bondstones should be inserted at frequent intervals, projecting quite through the wall, or well into the interior.

27. Stone quoins.—These are stones of large size placed at the angles of walls in order to give increased strength and add to the appearance. Those shown in figs. 66, 67, 69, and 70 for rubble walling are simply large stones of rough shape and irregular size. In fig. 72 the quoins or corner-stones are ashlar, having a chisel draft $1\frac{1}{2}$ inches wide sunk round the margin, the remainder being left rough as shown.

Fig. 73 illustrates the use in a brick building of quoin stones, standing out $1\frac{1}{2}''$ beyond the face of the wall, and having the edges or arrises chamfered. A projecting base or plinth of stone is also added for the sake of appearance and stability. Quoins for use with brickwork should be equal in height to a certain number of courses of the latter, in order to bond with it. It should be noticed that those stones appearing as headers on one face of the building will show as stretchers on the other.

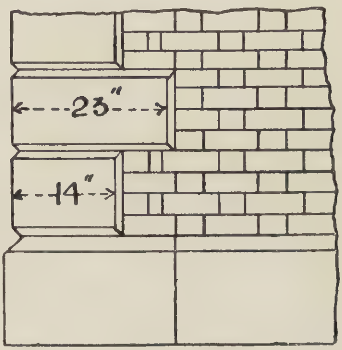


FIG. 73.

28. Dressings for window and door openings.—These are usually of cut stone, and when used with brickwork may be equal in height to 3, 4, or 5 courses of it. The stones are laid as headers and stretchers alternately, as shown in fig. 74. In the example given each header passes quite through the thickness of the wall, thus securing thorough bond.

The jamb is recessed for the reception of a window or door frame.

In practice it is usual, especially with thick walls, to let the header project into the wall from $4\frac{1}{2}$ to 9 inches beyond the stretcher.

29. Stone copings.—Several examples of these are shown in the present chapter. They **are usually** of York stone,

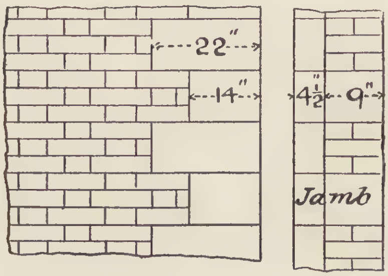


Fig. 74.

flat (fig. 69), **feather-edged** (fig. 67), or **saddle-backed** (fig. 66). The rule for the length of stones in walls, given previously, does not apply here. Long coping stones necessitate **fewer joints,** and thus diminish the chance of water finding its way into the body of the wall.

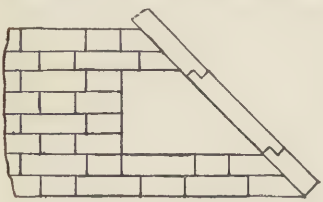


Fig. 75.

A **groove** or **throat** should be cut along the under side of the projecting part for the purpose already explained of keeping the water from dripping down the wall face.

The copings on steep gables and other sloping positions may be prevented from sliding down the incline by means of **dowels** inserted at intervals along the brickwork, and fitting into mortises in the coping. Stones termed **kneelers** are also used for the same purpose (fig. 75).

A **kneeler** may be described as a coping stone having worked on it a **horizontal bed** or **tail.** This latter is built

into the wall, thus forming an abutment for the stones above and preventing any downward motion.

The portion built into the brickwork is of course flush with it. The inclined part projects, and is throated so as to match the rest of the coping.

A stone of this description used at the **foot** of a coping is sometimes termed a **springer**.

Copings should be weathered—i.e. bevelled sufficiently to throw the water over to the roof or gutter, and away from the wall face.

Dowels, cramps, and **joggles** are used as connections between the coping stones, the latter joint being shown in fig. 75.

30. String course.—This term is applied to the ornamental band of cut stone which is frequently built across the face of a wall.

In the example given (fig. 76) the string, equal in depth to three courses of brickwork, projects $4\frac{1}{2}$ inches into the wall, and $2\frac{1}{2}$ inches beyond. Where possible it should be weathered and throated.

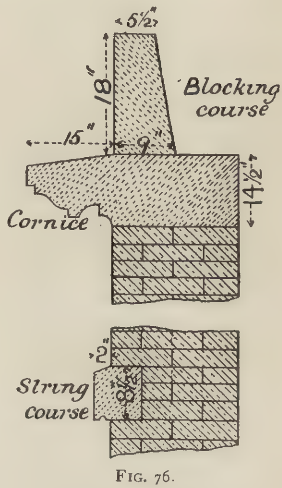


FIG. 76.

31. Cornices. — The projecting course of stone on the top of the wall in fig. 76 is known as a **cornice**. The upper surface standing out from the brickwork is weathered, the under portion being moulded.

The cornice shown extends the whole thickness of the wall. In any case care must be taken that sufficient of it rests on the wall to well balance the overhanging part.

A blocking course is very frequently added above the cornice (see fig. 76). This is of service in forming a gutter such as is shown in the chapter on **Leadwork**.

Exercises on Chapter III.

1. Plan and section of a joint secured by a metal cramp, fig. 56. Draw to a scale of $\frac{1}{6}$, showing the cramp 12″ long, $1\frac{3}{4}$″ wide, and $\frac{1}{2}$″ thick, with its ends turned down $1\frac{1}{4}$″ and the top $\frac{1}{4}$″ below the surface of the stone.

2. Draw to a scale of $\frac{1}{12}$ a sectional elevation of the joint shown in fig. 58, the stones to be in position.

3. Make scale drawings $\frac{1}{4}$ actual size of the joints given in figs. 61, 62, 63, and 64.

4. Vertical section of hanging stone steps. Draw to a scale of $\frac{1}{6}$, and add a front elevation showing the steps built 9″ into a 2 brick wall.

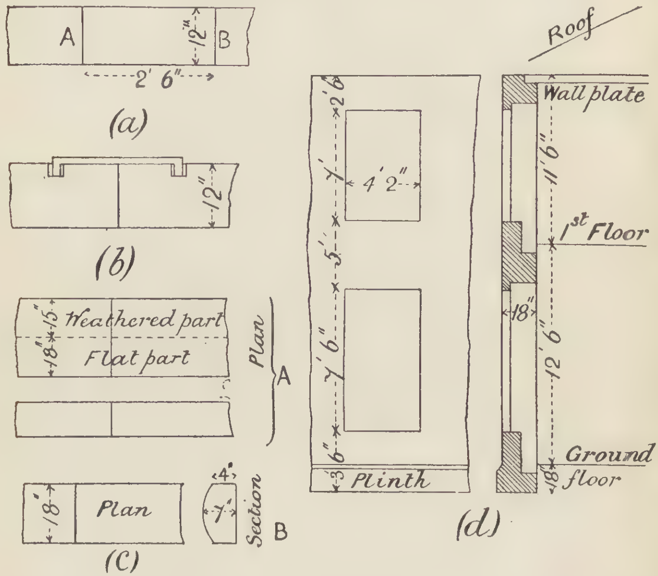


Fig. 77.

5. Part of the end of a common rubble wall with quoins and saddle-back coping (fig. 66). Draw to a scale of $\frac{1}{12}$.

6. Draw figs. 67 to 72 inclusive to a scale of $\frac{1}{12}$.

7. Section through a coursed rubble with brick backing, fig. 68. Draw to a scale of $\frac{1}{12}$ an elevation of the face, and also a horizontal section through the 9″ brickwork.

8. Elevation of a kneeler (fig. 75). Draw to a scale of $1\frac{1}{2}$″ to 1′ and add a horizontal section through the centre of the stone showing an 18″ coping for a $1\frac{1}{2}$ brick wall.

9. Vertical section through three coping stones, fig. 77 (*a*). Draw to a scale of $1\frac{1}{2}''$ to a foot, showing the joint A secured by a slate dowel and B by a joggle.

10. Section through two stones connected together by a metal cramp, fig. 77 (*b*). Draw to a scale of $1\frac{1}{2}''$ to a foot, making any alteration you may consider necessary, and naming the metal you would prefer for the cramp.

11. A shows the plan and section (the latter taken through the flat part) of a joint in a stone cornice to be secured by an iron cramp, fig. 77 (*c*). B shows the plan and section of a joint in a curb for a railing to be secured

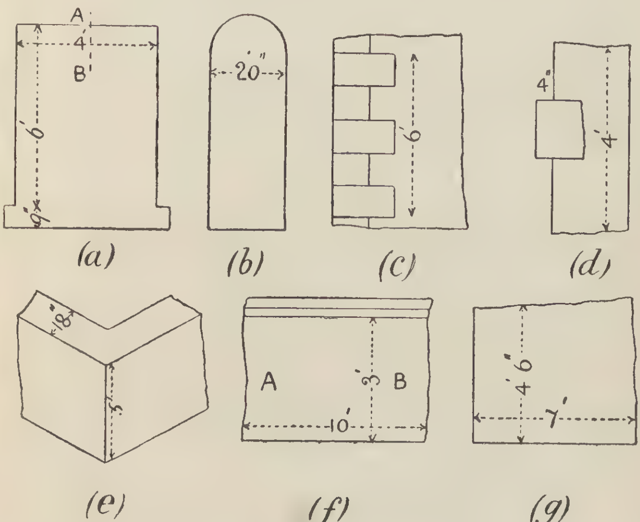


FIG. 78.

by lead plugs. Draw to a scale of $1''$ to $1'$, and complete the drawing in both cases, inserting the cramp in A and the plugs in B.

12. Outside elevation and section of the front wall of a brick house, fig. 77 (*d*). Draw to a scale of $4'$ to $1''$, add string course, window-sills and cornice with blocking course.

13. Elevation of a window opening in a brick wall 2 bricks thick, to be finished with stone dressings, fig. 78 (*a*). Draw to scale of $2'$ to $1''$, show window-sill, and dressings in elevation, marking the dimensions on them and give a section on A B.

14. Cross section of a common rubble wall with moulded brick coping, fig. 78 (*b*). Draw to scale of $\frac{1}{24}$, showing the stones and three courses of tile creasing.

15. Elevation of the end of a stone wall built of snecked or irregular coursed rubble, the quoins being hammer dressed with drafted margins, fig. 78 (*c*). Draw to a scale of 2′ to 1″, showing the class of masonry described.

16. Vertical cross section through part of a 20″ stone wall built in coursed rubble masonry with a 9″ ashlar string course, weathered and throated, fig. 78 (*d*). Draw to a scale of $\frac{1}{18}$, adding any details omitted.

17. An elevation of part of the angle of a stone building, fig. 78 (*e*). Draw to a scale of $\frac{1}{2}$″ to 1′ and fill in the joints of the masonry, showing coursed rubble from 4″ to 7″ thick, and block and start hammer dressed quoins with drafted margins.

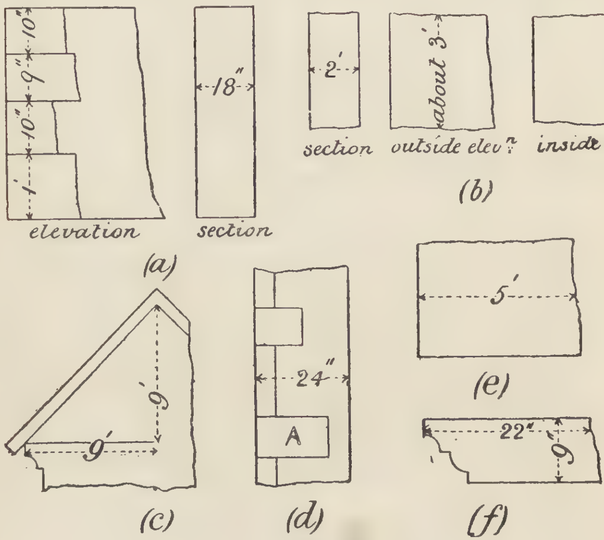


FIG. 79.

18. Elevation of part of a dwarf wall with stone coping, fig. 78 (*f*). Draw to a scale of $\frac{1}{24}$, showing at A coursed rubble, and at B irregular coursed or snecked rubble.

19. Front elevation of a wall 18″ thick, built in uncoursed rubble with brick quoins in English bond, fig. 78 (*g*). Draw to a scale of $\frac{1}{24}$ and give a plan of two courses of the brickwork showing the masonry.

20. Elevation and section of part of an 18″ stone wall in coursed rubble, fig. 79 (*a*). Draw to a scale of $\frac{3}{4}$″ to one foot, and fill in any joints of the masonry both in section and elevation, marking any bondstones with the letter B, no course being more than 1 foot high.

21. Section and elevations of part of a wall built of rubble masonry worked up to courses, and lined on the inside with $4\frac{1}{2}''$ of brickwork, fig. 79 (*b*). Draw to a scale of $\frac{1}{24}$, filling in the joints of the brickwork and masonry.

22. Part of the gable end of a stone building. Draw to a scale of $4'$ to one inch, showing an $8''$ cut stone string course about half way up the gable, and a portion above the string filled in with snecked or squared rubble, fig. 79 (*c*). The stone coping to be supported by kneelers, and the joints of the coping formed so as to keep out the wet.

23. Section of a coursed rubble wall faced with ashlar with a through bondstone at A, fig. 79 (*d*). Draw it to a scale of $\frac{1}{12}$, making any altera-

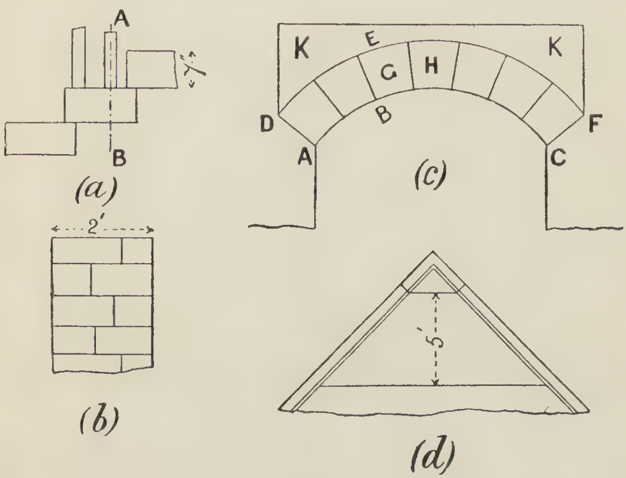


FIG. 80.

tion you may deem necessary in the ashlars, and filling in the joints of the rubble work.

24. Elevation of part of a stone wall built of squared rubble, built up to courses, fig. 79 (*e*). Draw to a scale of $2'$ to an inch, showing the arrangement of the stones.

25. Side view of a stone corbel to carry a girder, fig. 79 (*f*). Draw to a scale of $\frac{1}{12}$ a section of about 10 courses of an $18''$ brick wall, showing the bricks and the corbel in position.

26. End elevation of some stone steps, fig. 80 (*a*). Give a section through A B half full size, showing how the iron baluster is secured to the step.

27. Vertical section through the centre of the upper portion of a stone

pier, fig. 80 (*b*). Draw to a scale of $1\frac{1}{2}''$ to $1'$, showing a stone cap $12''$ deep at the centre, weathered and throated, and projecting $2''$.

28. Elevation of a stone arch, fig. 80 (*c*). Draw to twice the scale, writing against them the names of the following parts :—The lines A B C, D E F ; a single stone of the arch, as G ; the highest stone H of the arch ; the spaces K over the arch.

29. Part of the gable end of a stone building, fig. 80 (*d*). Draw to a scale of $\frac{3}{4}''$ to $1'$, showing on one half of the drawing common rubble masonry worked up to courses, and on the other coursed rubble masonry.

30. Take figure 79 (*e*) and draw to a scale of $\frac{3}{4}''$ to one foot. Mark by single lines the joints of uncoursed rubble masonry with ashlar quoins.

31. Give a sketch in elevation showing what is meant by snecked or irregular coursed square rubble.

32. Draw to a scale of $1''$ to a foot, a plan, elevation, and section of a stone window-sill $3'\ 4\frac{1}{2}''$ long $\times\ 10'' \times 6''$, sunk, weathered, and throated, with stopped ends. The window opening is $3'$ wide.

33. Give sketches of the following kinds of masonry :—Uncoursed rubble, coursed rubble, ashlar ; and give a section of a wall $18''$ thick in one of the two latter kinds showing the bond and heights of the courses in figures.

34. Give sketches of the following joints in masonry :—Cramp in a coping, joggle joint in a landing, dowel.

35. Show by sketches the difference between coursed rubble masonry and rubble masonry built up to courses.

36. Draw the section of three steps of a stone stair to a scale of $\frac{1}{4}$, showing the joints between them and the method of fixing iron standards to carry a handrail.

Tread from riser to riser $12''$, riser $5''$, standards $1''$ square.

37. Draw to a scale of $2''$ to $1'$ the elevation given in fig. 53 *b* showing below the window head on one side of the opening coursed rubble masonry with cut stone dressings, and on the other side uncoursed rubble, worked up to courses, and cut stone dressings.

38. Give a vertical cross section to a scale of $\frac{1}{2}''$ to a foot, through a stone wall built of rubble worked up to courses, to be $3'$ thick at the ground and to rest on an $18''$ bed of concrete $4'\ 6''$ wide, laid at a depth of $3'\ 6''$ below the ground. Show an asphalte damp course and a $6''$ offset for a wall plate $12'$ above the ground. Also a plinth $18''$ high, projecting $5''$, of cut stone, finished off with a chamfer.

CHAPTER IV.

WOOD JOINTS USED IN CARPENTRY AND JOINERY.

CARPENTRY.

32. General remarks.—In forming timber joints it may be laid down as a rule having few exceptions, that a simple form possesses greater strength than one more elaborate and complicated. This arises from two circumstances. (1) An intricate joint is more difficult to fit accurately. (2) It often requires the removal of a larger amount of material in its formation, thus rendering the connection weaker. Care must be taken in making joints to cut away the wood as little as possible, and also to ensure that all surfaces subjected to pressure are perpendicular to the direction of the force. Another point requiring attention is the arrangement of bolts and fastenings to the best advantage. It must be borne in mind that in boring a hole for a bolt the longitudinal fibres are severed, and thus the strength of the timber is diminished.

For many requirements such as beams, wall plates, etc., timber of sufficient length cannot be obtained. It therefore becomes necessary to unite two or more pieces lengthwise. This may be done by **lapping, butting,** or **scarfing,** the circumstances of the case determining which method is to be used.

33. Lapping, fig. 81 (*a*).—This is the simplest means of uniting two pieces of timber. The end of one is made to overlap that of the other, and the whole is secured by straps or bolts. Of the two fastenings mentioned the first is preferable, since the use of straps does not necessitate weakening the timber by cutting bolt-holes. No portion of the material being removed, this form of joint, though clumsy, gives the maximum strength.

Owing, however, to the horizontal surfaces being in three different planes, its use is limited.

34. Butting.—The defect just alluded to may be avoided

by using the connection shown in fig. 81 (*b*). The ends of the pieces are simply butted together and united by plates of wood or iron, known as **fish-plates,** bolted on opposite sides of the timber. A reference to the plan will show the bolts placed **zigzag** instead of in a straight line.

By this means the area of any cross section is reduced by only one bolt-hole.

The ends of one or both fish-plates, when of iron, may be

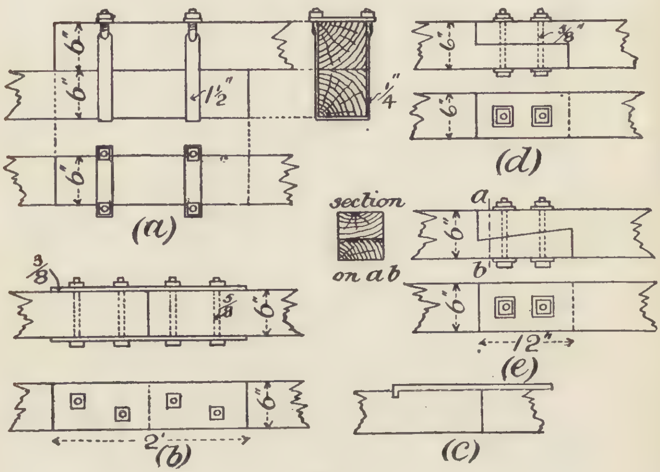


Fig. 81

turned down into shallow cross grooves, fig. 81 (*c*), thus assisting the bolts when subjected to tensional strain.

This is also known as a **fished joint.**

Lapped and butted beams are generally used for temporary structures—e.g. scaffolding, platforms for the construction of bridges, etc., as well as in permanent erections for rafters and plates.

35. Scarfing or splicing.—This method of uniting lengths of timber consists in cutting away corresponding portions of the thickness at the end of each piece. The remaining parts are overlapped and secured by bolts, straps, or fish-plates

according to the nature of the strains to which the joints will be subjected.

The same consideration also determines the form of scarf to be employed.

In fig. 81 (*d*) one half of the thickness has been removed from each piece. This is also termed a **half lap** or **halved joint.**

At fig. 81 (*e*) the surfaces are cut to a **bevel.** If the joint is

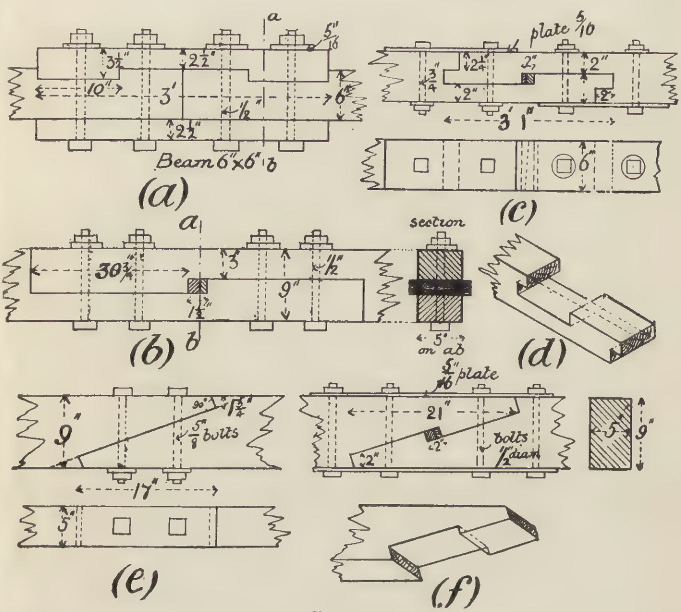


Fig. 82.

kept perfectly tight by means of bolts or superincumbent weight, the wedge-shaped portions tend to prevent the separation of the timbers when subjected to tension.

Fig. 82 (*a*) illustrates a **butt joint** with **wooden fish-plates.** The upper of these has two projections or **tables** worked on it, fitting into corresponding indents. The purpose of this is apparent. When iron fish-plates are not used, **broad washers** should be interposed between the heads and nuts of bolts and

the wood, in order to protect the fibres of the latter from being crushed.

Fig. 82 (*b*) shows a method of scarfing in which the pieces are **tabled** together. Before the bolt holes are bored the pieces are driven tightly together by means of **hard wood wedges** inserted from opposite sides as indicated.

This joint is well adapted to resist tension and compression.

A modification of the last-mentioned joint is shown in fig. 82 (*c*).

The proportion of wood removed is large, thus rendering the joint weak when subjected to cross strain. Fish-plates and bolts are shown in the figure for extra strength. They are not, however, absolutely necessary. The form of the joint would itself keep the parts in position.

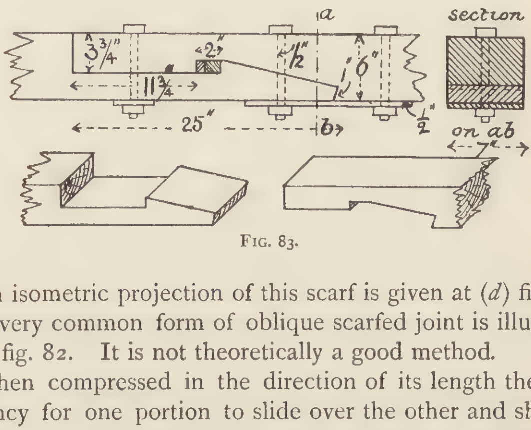


FIG. 83.

An isometric projection of this scarf is given at (*d*) fig. 82.

A very common form of oblique scarfed joint is illustrated at (*e*), fig. 82. It is not theoretically a good method.

When compressed in the direction of its length there is a tendency for one portion to slide over the other and shear off the angles as shown by the dotted lines, while any tensile strain to which it may be subjected comes entirely on the bolts.

A joint of this form having the upper splayed angle at 90° to the horizontal surfaces of the timber instead of at right angles to the oblique surfaces, as shown, is well adapted to resist cross strain.

At (*f*) fig. 82, the difficulty as to tension mentioned with the last example is obviated by tabling the two parts together.

A good joint for resisting transverse strain is shown in fig. 83.

The student should carefully examine each of the cases given as to its suitability for withstanding the three strains referred to—viz. tensional, compressive, and transverse.

36. Halving.—This has been already referred to. Fig. 84 shows two pieces joined together in this way at right angles. In fig. 85 the surfaces are bevelled. Wall plates are often connected in this way at angles.

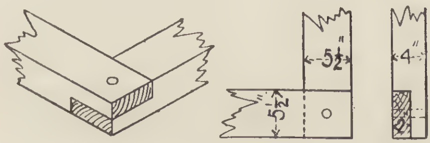


Fig. 84.

Dovetail halving is represented in fig. 86. At (*a*) is shown in plan and section the joint between two pieces of wood at right angles to each other. The end of one piece is checked out to one half its thickness, the remaining portion being cut to a dovetail form. This fits into a corresponding notch worked in the lower piece.

While the dovetail accurately fits this notch, its form is

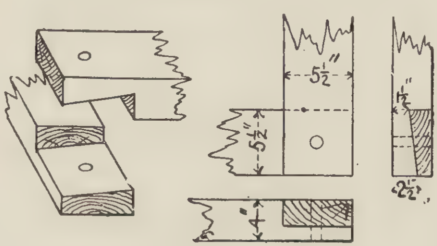


Fig. 85.

effective in preventing the separation of the parts. In course of time, however, it **shrinks** in **breadth** to a greater extent than does the notch (*b*) fig. 86. When this occurs the dovetail is no longer of service as such.

A joint of similar form to this may here be mentioned. It is used in forming a connection between the **collar beam** and **rafters** of a roof, fig. 86 (*c*).

The collar end in the example is cut to a half dovetail form, and checked out to a depth of $\frac{1}{2}$ inch. The rafter is notched $\frac{1}{2}$ inch deep to receive the collar beam. Nails or pins then secure the whole.

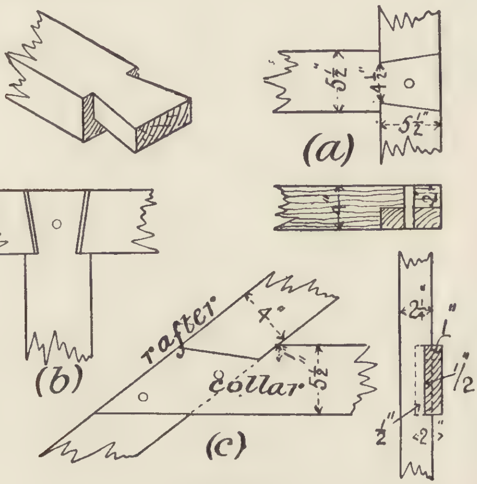


FIG. 86.

37. Notching.—A common way of fitting joists to wall plates is shown in fig. 87.

The joists are checked out or notched as it is termed, and

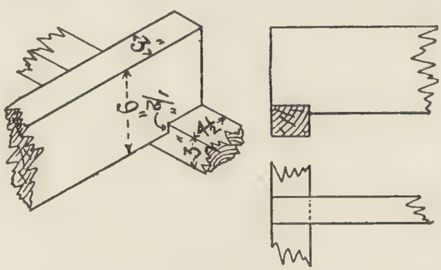


FIG. 87.

then spiked (nailed) to the plate. If space permits the end of the joist may project over the wall plate, the portion beyond serving to tie in the wall plate, fig. 88 (*b*).

If it is necessary that the notch be deep, it is advisable, in order to diminish the strength of the joist as little as possible, to cut half of it out of each timber. Fig. 88 (*c*) shows the notch in the plate. This is sometimes known as **double notching.**

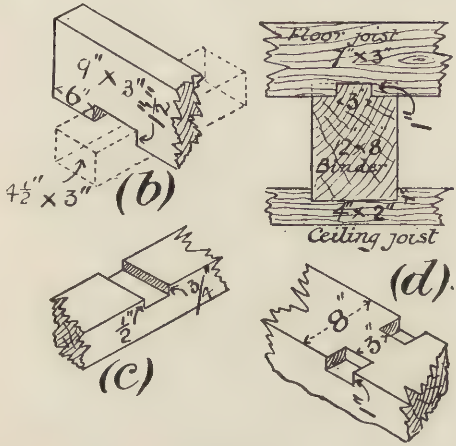


Fig. 88.

38. Cogging.—In the last figure mentioned the notch is cut the whole width of the wall plate, i.e. $4\frac{1}{2}$ inches. A much better plan is to cut it only partly across so as to leave a small **cog** to be grasped by the joist. Fig. 88 (*d*) shows a common

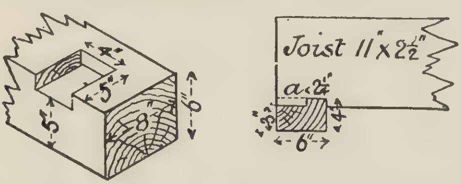


Fig. 89.

joist cogged to a binder. In this case the cog occupies a central position.

Fig. 89, however, is an example in which the cog is formed quite **at one side.** This is done when want of space does not

allow of the joist projecting beyond the plate, and it is desirable to have sufficient strength at *a* to resist any strain that may be brought to bear on it.

A better plan would be to have the cog about an inch from the inner side. Then the joist would be supported at a point where its depth is not diminished.

By some architects and builders, the notching and cogging of joists to wall plates is not countenanced, for the following reasons :—

(1) In notching, the removal of a portion of the depth of the joist is required, thus diminishing its strength, for which there is no adequate return.

(2) If in a single floor the wall plate is tied in by the joist,

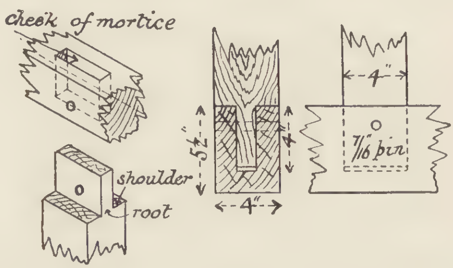


Fig. 90.

as in fig. 88, the vibration of the floor has a tendency to loosen the plate from the brickwork beneath.

In practice, therefore, it will be found sufficient to well spike the ends of the joists to the wall plates.

39. Mortise and tenon.—This is a joint in constant use for framing. Fig. 90 shows it. In forming this connection, equal rectangular pieces are cut out on both sides of a central portion which is termed a **tenon**. Usually its thickness is $\frac{1}{3}$ that of the timber on which it is worked. A rectangular hole or mortise cut in the other piece receives the tenon.

The **sides** of the mortise are called **cheeks**. These are indicated in the figure, as well as the **root** and **shoulders** of the tenon.

The isometric projection given in the figure shows a mortise

cut quite through the horizontal beam. When, as in the second case, the tenon is not intended to pass quite through the lower piece, the mortise should be a trifle deeper than the tenon in order that the shoulders of the latter, not its end, may receive any weight transmitted through the post. This remark applies to all framed work. The student will find a further reference to this point in connection with 'panels,' Chapter X.

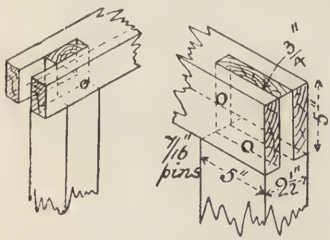


FIG. 91.

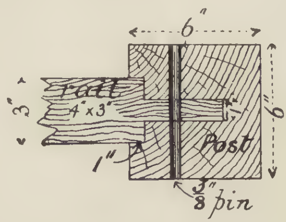


FIG. 92.

Pins used in securing the joint should be placed at a distance from the shoulders equal to $\frac{1}{3}$ the length of the tenon.

In fig. 91 two examples are given in which the mortise is cut through from the end of the timber.

40. Housed tenon.—A horizontal section through a **post** and **rail** is given in fig. 92. In addition to the mortise and

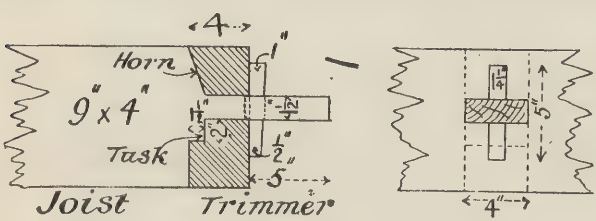


FIG. 93.

tenon the whole end of the rail is let into the post for a distance of 1 inch. By this means the strength of the joint is enormously increased. Any weight to which the rail may be subjected is carried by the whole thickness of the timber instead of by the tenon only.

This is known as a **housed tenon.**

41. Tusk tenon.—This form of tenon, similar in principle to the last, is shown in fig. 93.

Instead of housing the whole end of one timber into the other, a projection or **tusk** is introduced below the tenon. This affords a deeper bearing than the simple tenon, and greatly strengthens the joint. The part above the tenon is **splayed back** as shown, and is known as the **horn**. The tenon in fig. 93 passes quite through the trimmer and is secured by a wedge on the other side. Where this is inconvenient, as in the case of a tusk used in a thick girder, it will be sufficient if the tenon penetrates to a depth of $\frac{1}{3}$ that of the piece on which it is cut. It may then be pinned from the top of the girder.

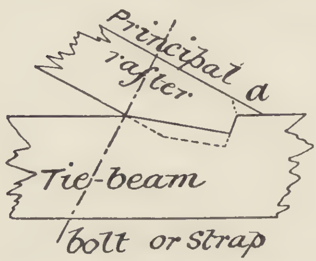


FIG. 94.

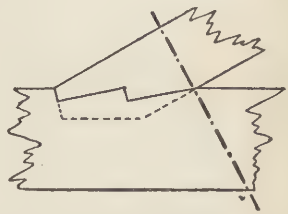


FIG. 95.

The following rules apply except in particular cases to this form of joint :

(1) The thickness of the tenon should be $\frac{1}{6}$ the depth of the timber on which it is cut.

(2) The tusk should penetrate to a depth equal to the thickness of the tenon.

(3) The lower edge of the mortise should be on the centre line or **neutral axis** of the timber in which it is cut.

42. Oblique tenons are used when the timbers are not at right angles. There are several forms in use. That shown in fig. 94 is common. The tenon is indicated by the dotted line. The toe *a* is bad in design. If subjected to a **downward thrust** in the direction of the rafter it would be liable to shear off.

Fig. 95 shows an oblique mortise and tenon with **double abutment**. If a **perfect fit** could be secured and **maintained**,

this joint would be very effective. Apart, however, from the difficulty of constructing it in the first place with accuracy, shrinkage and settlement are sure to occur, thus rendering one abutment valueless. Its use is, therefore, not advocated.

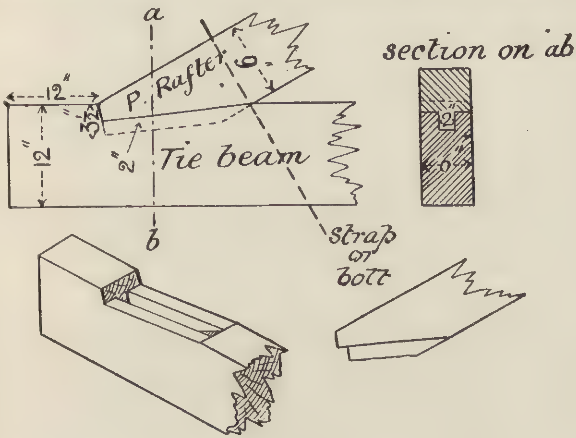


Fig. 96.

Perhaps the most effective oblique joint of this description is that illustrated in fig. 96. Here the minimum quantity of material is removed, and the joint is not difficult to make.

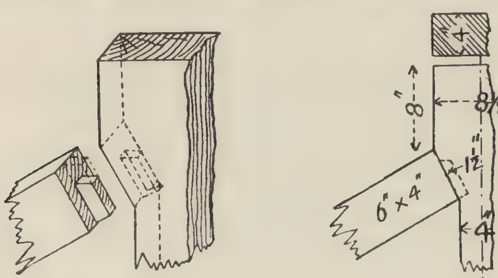


Fig. 97.

The tenon plays little part in resisting the thrust of the rafter. Its purpose is to prevent motion sideways. Any downward thrust is received by the whole breadth of the rafter. The abutment is formed by cutting down the sides of the mortise,

generally at right angles to the back of the rafter, in order that the bearing surface may be at **right angles to the line of pressure.**

In the same figure the tenon is shown cut back from the

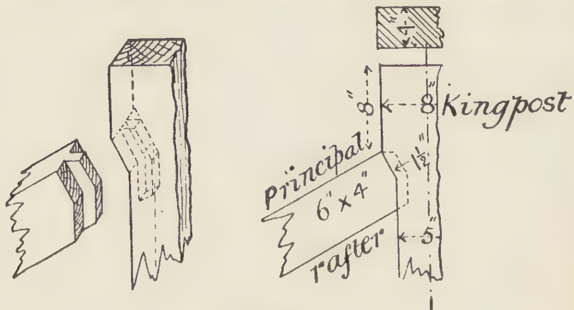


FIG. 98.

toe of the rafter. Care should be taken to keep the mortise as shallow as possible, so as not to greatly impair the strength of the tie beam.

The oblique joints just described may be secured by means of bolts or straps, the position of which has been indicated by

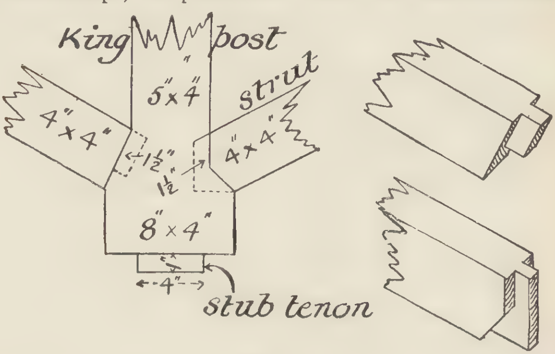


FIG. 99.

dotted lines. Their use is further illustrated in the chapter on Wood Roofs.

It is usual in practice when framing rafters into tie beams to leave the joint **slack at the heel of the rafter,** to allow for the settlement which inevitably occurs.

Figs. 97 and 98 show methods of jointing used between the **head of a post** and an **inclined beam,** the timbers chosen for illustration being the principal rafter and king post of a wooden roof truss.

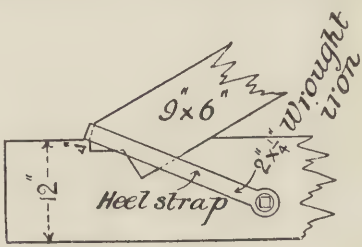
In fig. 97 the head of the king post is large enough to allow of a square abutment the whole depth of the rafter.

This is not the case in fig. 98. The end of the rafter has therefore been cut so that a portion at least of the bearing surface is at right angles to the direction of the pressure. The upper part of the joint should be left slightly open, otherwise when the framing settles into its position the pressure will be unevenly distributed.

The remarks made above with reference to figs. 97 and 98 will also apply to fig. 99, which represents two forms of the joint between a strut and the foot of a king post.

43. Bridle joint.—Fig. 105 shows this form of connection used at the foot of a principal rafter. The tenon or **bridle** is formed on the tie beam and the corresponding mortise cut in the rafter.

This form of joint presents a large bearing surface. The heel strap shown in the illustration is arranged so as to take the thrust of the rafter and thus assist the joint.



44. Stub tenon.—In fig. 99 a short tenon 1 inch long is shown at the foot of the king post. It fits into a mortise in the tie beam, and has for its object the prevention of lateral motion. This is known as a **stub tenon.** Another example of this form of tenon, given in fig. 101, is frequently used in securing the **posts** of a partition **to the head and sill.**

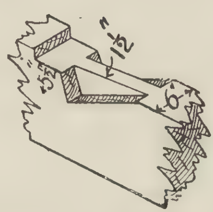


Fig. 100.

45. Dovetail tenon.—The tenon shown in fig. 102 has one side cut back so as to form a half dovetail. The mortise is made sufficiently wide to allow the broad end of the tenon to

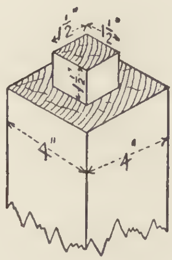


Fig. 101.

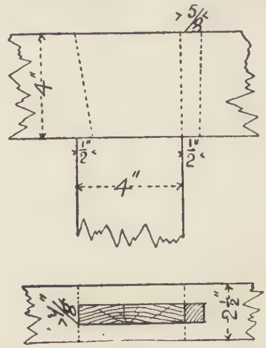


Fig. 102.

pass through. It is then tightened up by driving in a wedge along the straight side of the tenon.

46. Wedging.—Fig. 103 shows the method of wedging adopted in order to securely fix an ordinary tenon in its place.

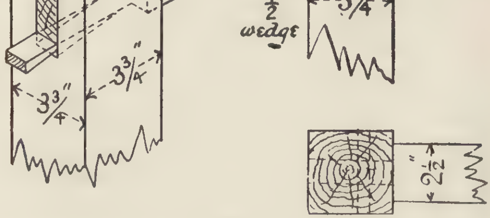


Fig. 103.

The mortise is slightly wider on the side farthest from the root of the tenon. Into the spaces thus left, wedges dipped in glue are driven tightly. White lead should be substituted for glue in outside work.

Fox wedging.—The method just described can only be used in cases where the end of the tenon is visible.

In fig. 104 the mortise penetrates only partly the thickness

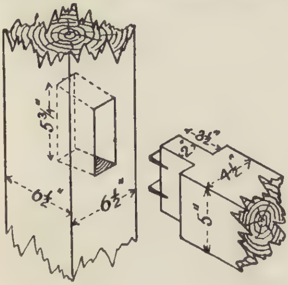


FIG. 104.

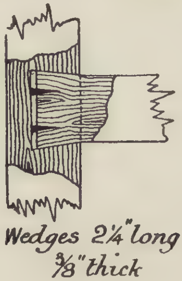


FIG. 105.

of the post. Hence it is impossible to insert the wedges from the back.

Saw cuts are therefore made across the end of the tenon into which the wedges are stuck. On driving home the tenon it is split and opened out so as to fill up the mortise, which is enlarged at the back.

The dovetail form thus given to the tenon is shown in fig. 105.

47. Birdsmouth.—This term is given to the **angular notch** cut in one piece of timber so as to make it fit obliquely on another.

In fig. 106 a birdsmouth is shown at the junction between a common rafter and pole plate.

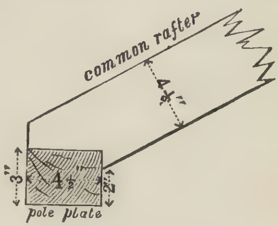


FIG. 106.

When rafters are required to project beyond the wall so as to form an eaves, they are checked out in a similar manner in order to fit the edge of the wall plate. See Chapter VII.

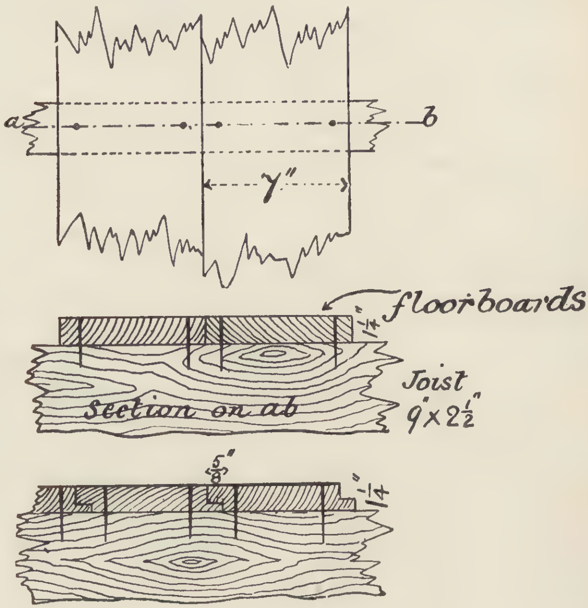
JOINERY.

48. General remarks.—The joints to be described are those used by the joiner in constructing **doors, windows, staircases, floor boards,** etc.

The carpenter is employed on such woodwork as is requisite for the **construction** and **stability** of an edifice.

Joiner's work comprises, in general, the wood **fittings**, internal and external, which are necessary for its completion.

As most of the joinery is open to view, great care is required (1) in selecting **suitable well-seasoned materials**, free from sap, shakes, large dead or loose knots, and wany edges; and



FIGS. 107 and 108.

(2) in fitting all joints **accurately**. For inside work glue is used in certain joints; if exposed to the weather, white lead should be substituted.

When a piece of work consisting of several parts, such as the framing of a door, has to be put together, the joints are all glued at one time, the pieces put into position, and forced home with the assistance of cramps.

In joinery the wood generally used is in the form of **boards**

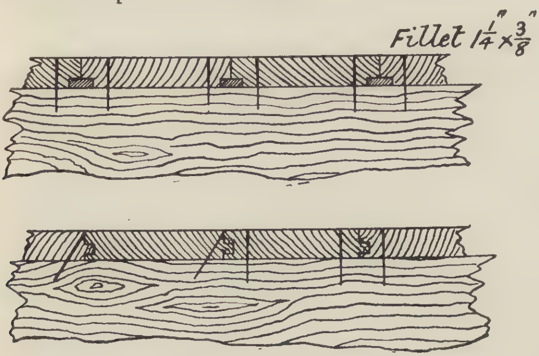
of various thicknesses, not in **scantling** as for carpentry. The ill effects of bad seasoning—viz. **warping, twisting,** and **shrinking**—are therefore more apparent.

Hence it is advisable to use as narrow widths as possible when the surface to be covered is large.

The following seven joints are illustrated in connection with flooring.

49. **Butt joint.**—This is formed by simply planing the edges of the boards true and placing them in contact.

Fig. 107 illustrates, in plan and section, two floor boards butt jointed and nailed to the joist. The defect is, that when shrinkage occurs in the width of the stuff, an opening will be left the whole depth of the boards.



FIGS. 109 and 110.

50. **Rebated joint.**—In this form of joint a rectangular slip is cut from the edge of each board and the remaining portions are overlapped as in fig. 108.

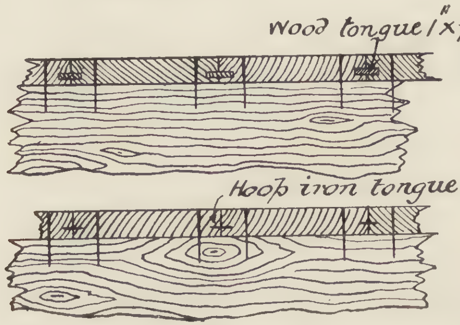
The drawback mentioned in the last case is here avoided.

51. **Rebated and filleted joint.**—Fig. 109 illustrates this connection. A rebate is worked along the lower edge of each board into which is placed a slip of hard wood termed a **fillet.**

52. **Grooved and tongued joint.**—Along the edge of one board is worked a **tongue** which fits into a **groove** cut in the edge of the other, fig. 110.

53. **Rebated, grooved, and tongued joint.**—This is illustrated in Chapter V., fig. 142.

54. Ploughed and tongued joint.—Figs. 111 and 112 show joints of this description. A narrow groove is cut along the edge of each board with a plough, and a strip of **hoop iron** or **hard wood** inserted. These strips are known as **tongues** or **slip feathers.**



FIGS. 111 and 112.

It will be noticed that in the preceding figures the **rebates, tongues,** and **grooves** have been kept as close to the lower surface of the floor boards as possible. It must be remembered that all wear comes on the **top** of the boards. The object, therefore, is to meet this wear by leaving a greater thickness of material where it is most required.

55. Dowelled joint.—Dowels are small pins of hard wood, generally **round,** fixed at intervals along the edge of one board, and fitting into corresponding holes in the edge of another. Dowelled floor joints are only used in high-class work.

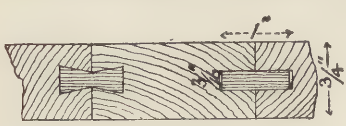


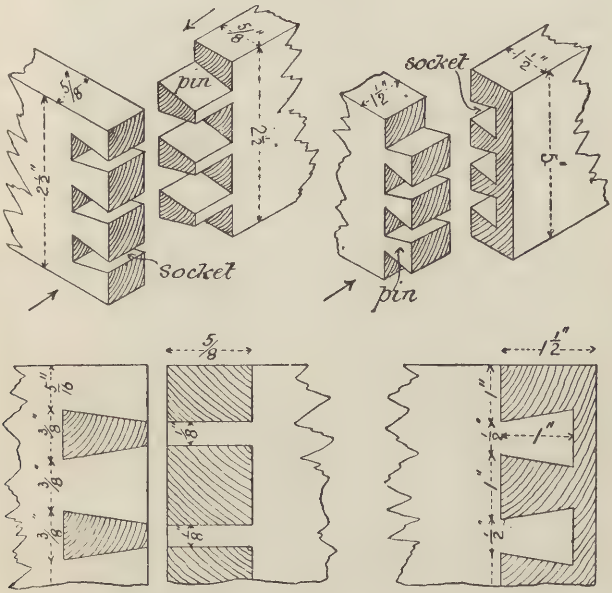
FIG. 113.

56. Slip feathers.—These should be cut across the grain, i.e. the grain should run at right angles to their length. When this is the case they are known also as **cross tongues.**

Fig. 113 shows the use of slip feathers. One of them is dovetail in section, and consequently must be pushed **endwise** into position.

57. Mortise and tenon joints.—These have been already described in connection with carpentry. Their use in joinery for door framing is illustrated in Chapter VIII.

It will be noticed, on referring to the examples there given, that the tenons are partly cut away to within $\frac{1}{2}$ inch of the root. This is known as **haunching.**



FIGS. 114 and 115.

The portion thus left adds greatly to the **lateral stiffness** of the tenon, while at the same time the mortise need not be so large.

58. Dovetail joints are formed by cutting a series of **pins** on the edge of one board, and a corresponding series of **sockets** on the other. These fit together and form an admirable joint for angular work. Two examples are shown.

In fig. 114 the joint shows on both sides of the angle. This is known as **common dovetailing.**

Lap dovetailing is illustrated in fig. 115. In this case the sockets **are not cut quite through** the thickness of the board. The dovetails are therefore visible on **one face only.**

The method of putting the joints together is indicated by arrows.

59. Beads.—These are used by the joiner for the purpose of adding a finish to his work, and also to hide, by means of the shadow cast from the rounded portion, any opening which may occur from shrinkage. Such an opening is also less noticeable when matched on the other side of the bead by the groove or quirk cut in forming it. This is shown in fig. 118.

When a bead is cut on the board itself, it is known as a **stuck bead.** If made in a separate piece and secured to the work with small nails or brads, it is said to be **planted.**

The following beads are in common use :—

60. Quirked bead.—At A, fig. 116, is shown a **quirked bead** used for the purpose already explained. Such a joint as this—viz. **grooved, tongued, and beaded**—is employed in putting together narrow widths of thin stuff known as **match-boarding.**

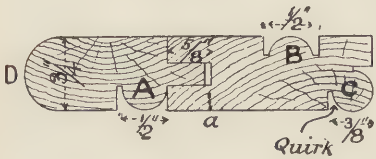


Fig. 116.

The bead must always be worked on the edge, which is tongued. The reason is obvious. A quirk cut at the dotted line *a* would greatly weaken the joint.

An example of the use of a quirked bead with a rebated joint is shown in fig. 118.

V-joints are now frequently used for match-boarding.

Fig. 116 *a*.

Referring to fig. 116 *a*, it will be seen that notwithstanding shrinkage the joint is still symmetrical.

61. Double quirked bead.—This is shown at B, fig. 116. A bead of this description is often run down the centre of a board in order to give it the appearance of two narrow ones joined together.

62. Staff bead.—A bead worked along the **arris** of a piece of stuff is known as an **angle** or **staff bead** (C, fig. 116). It not only adds to the appearance of the work, but is also less liable to injury than a sharp edge would be.

63. Round-nosing is shown at D, fig. 116. The projecting edges of **window boards, stair treads,** etc. are usually finished off in this way.

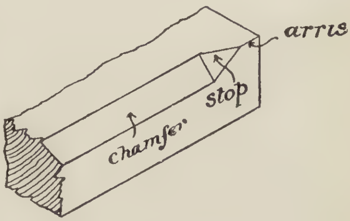


FIG. 117.

64. Chamfering.—This is illustrated in fig. 117. Besides being ornamental, it serves the same purpose as a staff bead. In the example given, the chamfer is not carried quite along to the end of the board. The termination is called a **stop,** and the edge is said to be **stop-chamfered.**

65. Cocked bead.—At D, fig. 119, is shown a cocked bead (so called, because it projects above the surface), which is made in a separate piece and **planted** on the surface of the board. A better plan is to lay it in a shallow groove, about $\frac{1}{4}$ inch deep, cut to receive it.

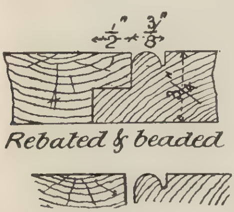


FIG. 118.

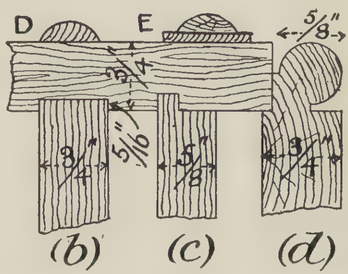


FIG. 119.

At E, fig. 119, the bead is shown resting on a **fillet.** This is known as a **cocked bead** and **fillet.**

The following joints for boarding are shown on the same figure :—

(1) **Housing.**—Fig. 119 (*b*).

(2) **Groove** and **tongue.**—Fig. 119 (*c*).

(3) **Rebate, butt,** and **staff bead.**—Fig. 119 (*d*).

Exercises on Chapter IV.

1. Draw the joints shown in fig. 81 to a scale of $\frac{1}{6}$.

2. Draw the joints given in fig. 82 to a scale of $\frac{1}{6}$, and in each case add a cross section through one of the bolts.

3. Draw fig. 83 to a scale of 2″ to 1′ and show its plan.

4. Plans, elevations, and isometric projections of two halved joints, figs. 84 and 85. Draw to a scale of $\frac{1}{6}$.

5. Give an isometric projection of fig. 86 (*a*) to a scale of $1\frac{1}{2}''$ to 1′.

6. Draw the joint fig. 86 (*c*) to a scale of $\frac{1}{8}$, and add a horizontal section through the middle of the collar.

7. Draw figs. 87, 88, and 89 to a scale of $\frac{1}{4}$, showing fig. 88 (*c*) with a $9 \times 2\frac{1}{2}$ joist in position.

8. Draw fig. 90 one half full size, and give a horizontal section $\frac{1}{2}''$ below the root of the tenon.

9. Give to a scale of $\frac{1}{8}$ a plan and two elevations of each of the joints shown in fig. 91.

10. Fig. 92 is a horizontal section of the joint between a post and rail. Draw to a scale of 3″ to 1′, and show also an elevation, the post to be 2′ high and the upper edge of the rail 6″ below the top of the post.

11. Draw fig. 93 to a scale of $\frac{1}{4}$, showing also a plan of the joint.

12. Draw to a scale of $1\frac{1}{2}''$ to a foot the joint between a principal rafter and tiebeam represented in fig. 96. Show it secured by a bolt $\frac{3}{4}''$ in diameter.

13. Draw the joints given in figs. 97, 98, and 99 to a scale of $\frac{1}{6}$, showing the head of the kingpost complete.

14. Draw the bridle joint shown in fig. 100 to a scale of $\frac{1}{8}$. Add a plan and cross section taken through the joint at a distance of $4\frac{1}{2}''$ from the toe of the rafter.

15. Head of a post, fig. 101. Draw an elevation and plan showing it mortised into a horizontal beam 6″ deep and 4″ wide.

16. Fig. 102 is the plan and elevation of a dovetail tenon. Draw this $\frac{2}{3}$ full size.

17. Draw figs. 103, 104, and 105 to a scale of $\frac{1}{4}$.

18. Fig. 106 is a view of the joint between a common rafter and pole plate. Draw to a scale of $\frac{1}{3}$, adding a plan and second elevation, the rafter being $2\frac{1}{4}''$ thick.

19. Draw all the joints shown in figs. 107 to 113 inclusive to a scale

of $\frac{1}{2}$. The floor boards are to be 7″ wide and 1″ thick, joists $2\frac{1}{2}$″ thick. Give a plan in each case.

20. Figs. 114 and 115 show two methods of dovetailing together pieces of stuff at right angles. Draw full size the views given.

21. Draw full size the beads and joints shown in figs. 116, 118, and 119.

22. Show by sketches what is meant by the terms fox wedging and chase mortise.

23. Give drawings to a scale of $\frac{1}{12}$, explaining fully the following details :—A butt joint, the timber being 9″ × 9″ and secured by $\frac{1}{2}$″ iron fish-plates; also the foot of a 12″ × 12″ story post mortised into a stone base 16″ × 16″ × 12″, the top of the base to be chamfered.

24. Show by sketches the meaning of the following terms :—Match-boarding, mortise, and tenon; haunched tenon. State the object of the latter.

25. Explain by sketches the following joints in carpentry :—Housed, ploughed and cross tongued, rebated, dovetailed.

26. Give sketches of the following joints in carpentry :—Notching, cogging, shouldered tenon.

27. Give sketches showing the difference between scarfing and fishing the ends of timbers together.

28. Give sketches showing the meaning of the following terms in carpentry :—Stump tenons, fox wedging.

29. Draw to a scale of 2″ to a foot a section of the following joints :—(*a*) Joint of a trimmer $10\frac{3}{4}$″ × 3″ with a trimming joist $10\frac{3}{4}$″ × 3″ by shouldered tenon, writing the name of each part on it. (*b*) Joint in the tie beam 12″ × 5″ of a timber roof, by a scarf, showing ironwork.

30. Give sketches of the following joints in carpenter's work :—Fished joint, scarfed joint, mortise and tenon, cogged joint.

31. Draw freehand the following :—Dovetail joint, rebate, chamfer, plough groove, return or double quirk bead.

32. Give sketches showing the meaning of the following terms :—Staff or angle bead, ploughed and cross or feather tongued, dovetail halving, tusk tenon.

33. Draw to a scale of $\frac{1}{3}$ a cross section of (1) a 3″ deal with one edge chamfered and one edge beaded; (2) a 2″ batten tongued and grooved.

34. Give a cross section $\frac{1}{4}$ full size through three $1\frac{1}{4}$″ floor battens, showing the difference between rebated and filleted, and ploughed and tongued joints.

35. Draw freehand the following joints and mark on them the scantling of the timbers :—Wall plates $4\frac{1}{2}$″ × 3″ at the angle of a building by halving, bridging joist 8″ × $2\frac{1}{2}$″ with a girder 14″ × 11″ by notching; joint in a tie beam by fishing, tie beam 13″ × 18″; joint in the same tie beam by scarfing.

36. Section through some inch battens secured to the rails of a framed partition, fig. 120 (*a*). Draw $\frac{1}{4}$ full size, showing three different ways of

closing the joints between the battens so as to guard against the effects of shrinkage. Write the names of the joints on them.

37. Cross section of four battens $5'' \times 1\frac{1}{2}''$, fig. 120 (*b*). Draw $\frac{1}{3}$ full size, showing a rebated and beaded joint at A, a ploughed and tongued joint at B suitable for floor boards, and a rebated and filleted joint at C for the same purpose.

38. A is the plan and B the elevation of the end of a timber balk, fig. 120 (*c*). Show at A two such balks connected by $\frac{1}{2}''$ iron fish-plates, and at B by halving, to a scale of $1\frac{1}{2}''$ to a foot.

39. Plan of timbers crossing one another, fig. 120 (*d*). Draw to a scale of $\frac{1}{6}$ two sections through A A, the first to be marked A showing a notched joint, and the second to be marked B showing a cogged joint.

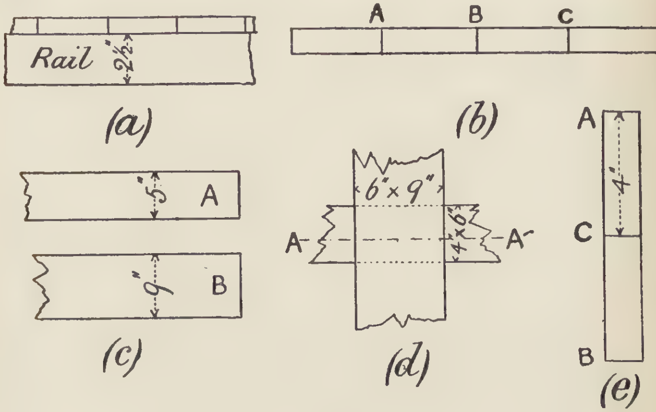


FIG. 120.

40. Cross section of two wrought battens $\frac{3}{4}''$ thick, fig. 120 (*e*). Draw them $\frac{1}{2}$ full size, showing a rebate at A, round nosing at B, and a grooved and tongued and beaded joint at C.

CHAPTER V.

FLOORS.

66. General remarks.—The term **naked flooring** is applied to the collection of timbers used to carry the floor boards.

In laying out a floor the principal timbers—i.e. those by which the weight is chiefly supported—should, except in special cases, cross the floor space in the **shortest** direction.

The timbers referred to are the **common joists** of single floors, **binders** in double floors, and **girders** in framed floors.

Timber being seldom perfectly straight, care should be taken to keep the rounded side upwards. This allows for settlement which is sure to take place, however well proportioned the timbers and well made the joints.

Ordinary dwelling-house floors should be capable of sustaining a weight of 140 lbs. per square foot without deflection.

In practice the ends of joists, etc., are generally built into the wall. This method is, however, open to grave objection.

It has been found that timber, when unexposed to a free current of air, is very liable to a form of decay known as '**dry rot,**' in which the woody tissue is decomposed and rendered brittle and worthless by the growth of a fungus. This decomposition is favoured by **want of ventilation,** and therefore invariably attacks timber when built into walls unless means are taken to prevent it.

This may be done by leaving a clear space round them through which air may circulate.

All wooden floors should for the same reason be thoroughly ventilated between the floor boards and ceiling below, by means of air bricks built into the wall in such a manner as to cause a **current** of air. Bricks should be left out here and there in internal walls to form this current.

Floors may be classified as follows :—

(1) **Single floors,** consisting of common joists and floor boards.

(2) **Double floors,** consisting of binders, common joists, and floor boards.

(3) **Framed floors,** consisting of girders, binders, common joists, and floor boards.

In each of these cases ceiling joists may be added to carry laths for the ceiling below.

67. Single floors.—In this arrangement, fig. 121, which is adapted for spans not exceeding 18 feet, the floor boards are

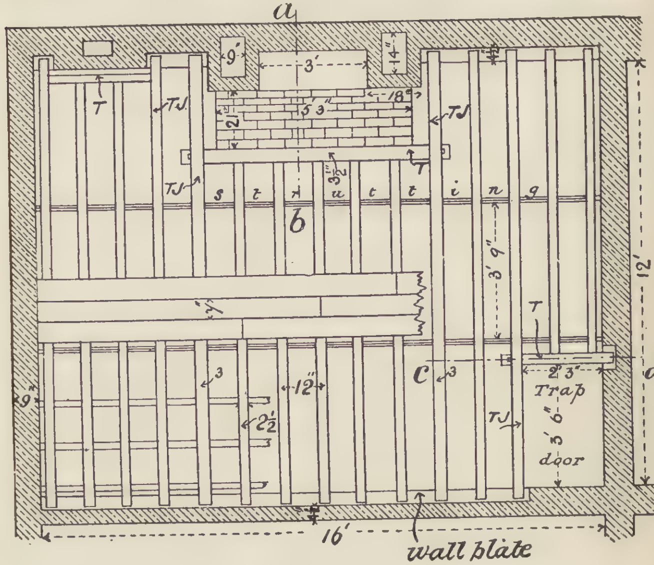


FIG. 121.

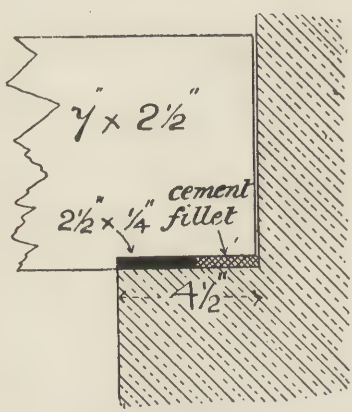


FIG. 122.

carried by timbers known as **common** or **bridging joists,** set on edge at intervals usually of 12 inches from centre to centre, and crossing from wall to wall without any intermediate support. The ends of the joists are generally supported by **wall plates,** to which they are spiked.

These wall plates may be either built into the wall or supported by corbelling out the brickwork. In ground floors the plates

are generally carried on an offset from the wall (see Chapter II.).

Another method of supporting the ends of joists, lately introduced in some important building works, is shown in fig. 122.

A strip of iron $2\frac{1}{2}$ inches wide and $\frac{1}{4}$ inch thick is laid along the inner edge of the wall. A cement fillet is run in to the level of the iron, so as to provide a $4\frac{1}{2}$ inch bearing for the joist.

68. Trimming.—A reference to the plan of a single floor shown in fig. 121 will show that at certain parts the joists, instead of being carried quite across from one wall to the other, are secured to cross pieces, which are themselves carried by the bridging joists.

The cross pieces T (fig. 121) are called **trimmers,** and the joists carrying them **trimming joists,** T U, fig. 121.

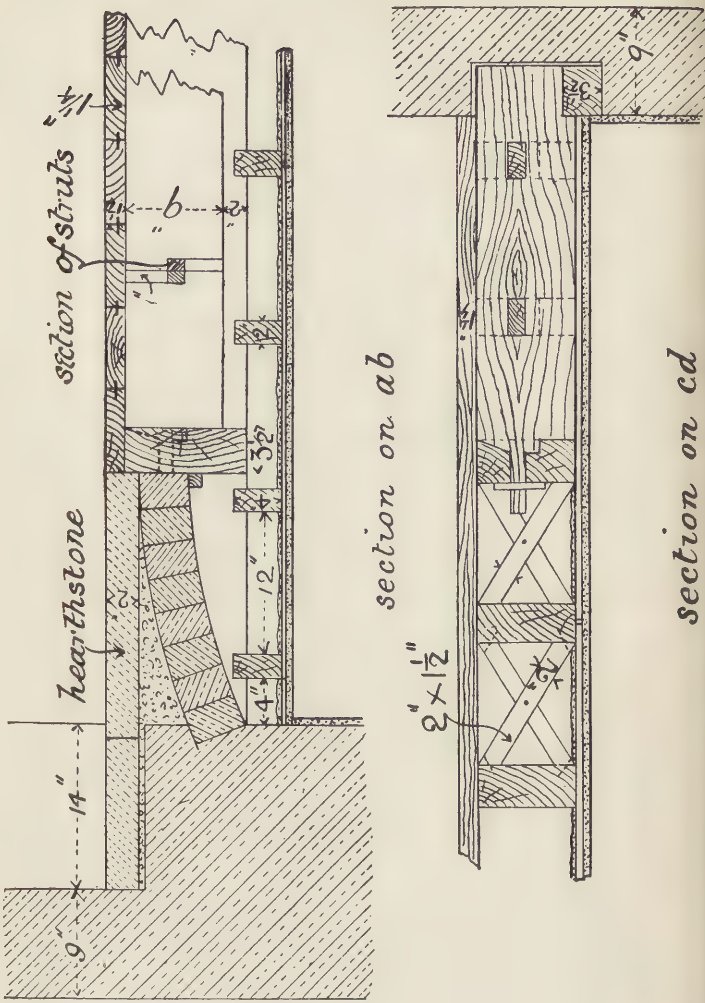
Three examples of trimming are given—viz. (1) To avoid running joists into the wall in close proximity to a flue. (2) Trimming round a hearth. (3) Trimming for a trap-door opening. The trimming joists should be stouter than the others, having to carry a greater weight. Tredgold says that an additional width should be given to each trimming joist of $\frac{1}{8}$ inch for each common joist carried by the trimmer.

In framing joists into trimmers, and trimmers into trimming joists, tusk tenons should always be used.

69. Ceiling joists.—These are shown in plan at the lower left-hand corner of fig. 121, secured to the underside of the bridging joists. To them are nailed the laths for carrying the plaster ceiling. A good plan is to make every fifth or so ceiling joist deeper than the rest (see fig. 140). The ceiling, being connected to the floor at fewer points, is thus rendered **stiffer** and less liable to crack. At the same time sound is transmitted through the flooring to a less degree.

The practice of adding ceiling joists to single flooring is, however, unusual.

The section shown in fig. 124 has been slightly modified in order to illustrate the method very commonly used of attaching



Figs. 123 and 124.

Note.—These sections refer to fig. 121.

laths **directly** to the common joists without the intervention of ceiling joists.

Laths should be laid about $\frac{5}{16}$ inch apart, never less. Into the spaces thus left the plaster is forced, so as to form a key to prevent it dropping away.

70. Trimmer arch.—In order to support the hearthstone a **half arch** may be thrown across the space between wall and trimmer (see fig. 123), the space above the arch being filled up to the level of the crown with Portland cement. In this the hearthstone is bedded.

Occasionally a trimmer arch is carried beyond its crown, as in fig. 125.

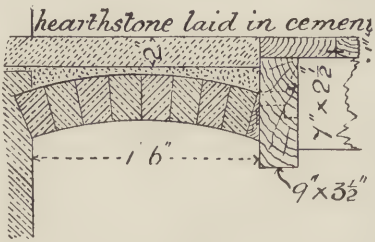


FIG. 125.

When this is the case, a **triangular wood fillet** must be nailed along the trimmer in order to provide an abutment.

Ceiling joists are shown in fig. 123. If these are to be dispensed with, and the laths carried by the joists, short pieces termed **bearers** must be inserted between the trimmer and wall, to which the laths may be secured.

The hearthstone usually extends 9 inches on each side of the fireplace. The trimmer arch should be 9 inches longer than the hearthstone.

71. Strutting.—When common joists are used for spans of more than 9 or 10 feet there is a want of stiffness, and a tendency for them to turn over sideways.

This may be remedied by the use of **herringbone** or **solid strutting.**

In **herringbone strutting** (see figs. 121, 123, and 124), pieces of wood about 2 inches wide and $1\frac{1}{2}$ inches thick are placed diagonally between the joists and nailed to them. An isometric projection of two joists with herringbone struts is shown in fig. 126.

Solid strutting consists of rectangular pieces of board nailed in between the joists. A section of a solid strut is

shown in fig. 137. It need hardly be added that, in order to produce the full stiffening effect, strutting must be arranged in continuous lines.

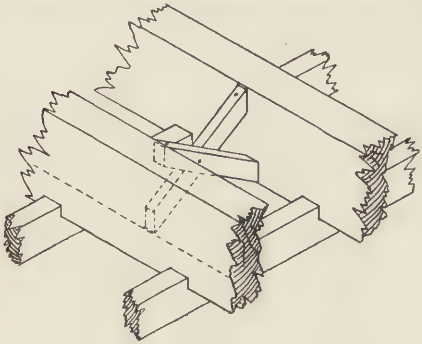


Fig. 126.

After the struts are placed in position **iron tension rods** are sometimes passed through the joists at right angles to them.

By screwing up the nuts at the ends of these rods, the struts are compressed and the floor considerably stiffened.

In ground floors the joists are usually supported at one or more intermediate points, on wooden plates or sleepers carried by dwarf or sleeper walls. An example is given in fig. 127.

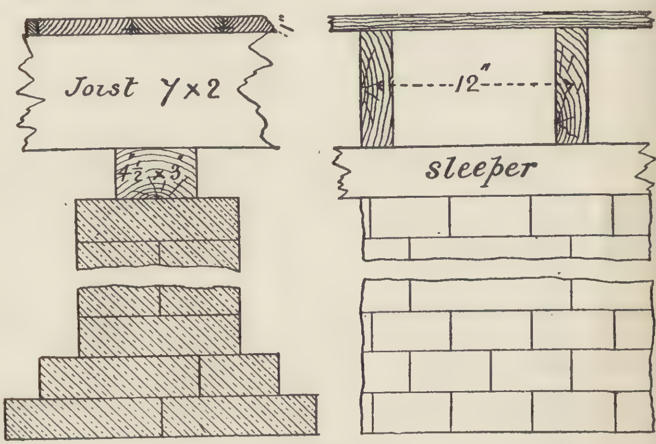


Fig. 127.

Note.—A **damp course** should be inserted in all sleeper walls, and spaces left for the circulation of air. Floors have been known to rot and give way through the omission of these details.

72. Double floors.—A double floor, as already mentioned, comprises floor boards, bridging joists, binders, and (if ceiled) ceiling joists.

Fig. 128 shows the plan of part of a double floor, the ceiling joists and floor boards being omitted.

Fig. 129 shows an enlarged section on the line *c d*, fig. 128.

In this system of flooring the weight is chiefly supported by the binders, which should be placed about 6 or 7 feet apart.

The common joists are cogged on to the binders, the ends of which are in the case illustrated carried by **hard stone templates** built into the wall.

By this means the weight is more evenly distributed over the brickwork beneath. The remarks made with regard to bridging joists when speaking of single floors, apply with equal force in the case of double floors.

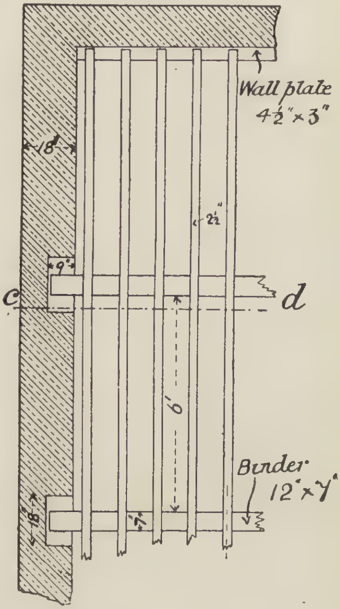


FIG 128.

The style of flooring just described has several advantages over the simpler form of single floors. It is much stronger and stiffer. The bridging joists being supported at intervals of 7 feet or thereabouts, are not so liable to sag as in the case of single floors.

In Manchester and the North of England warehouse floors are constructed in a manner similar to that shown in fig. 128, only the joists (usually 9 × 3 inches) are grooved and tongued with hoop-iron, and laid flatwise, so as to serve the purpose of floor boards. This makes a very strong floor, and one ad-

vantage is, that the underside forms a ceiling without further expense or waste of headway.

73. Ceiling joists for double floors.—These may be secured to the binders in the same way as in single flooring. They are notched and nailed to the under surface of the common joists. In some cases, however, it is desirable to keep the space occupied by the timbers of a double floor as shallow as possible.

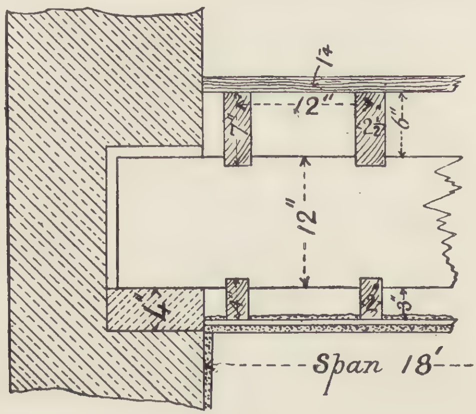


FIG. 129.

To effect this the ceiling joists may be fixed by one of the two methods shown in fig. 130.

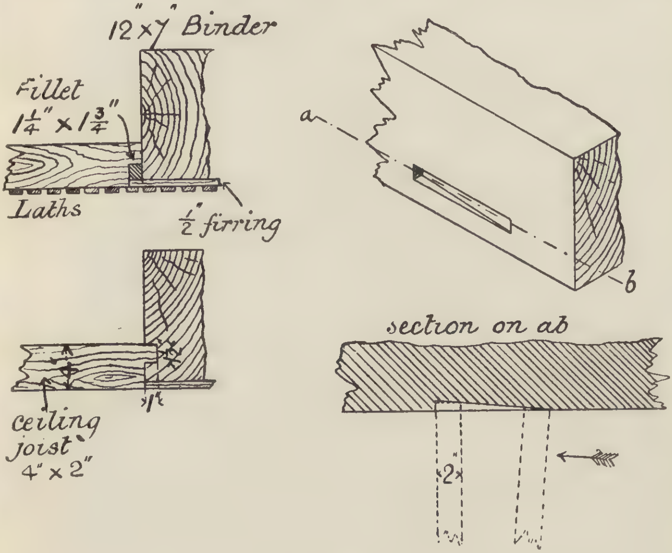
In the first of these a rectangular fillet is nailed along the lower edges of the binders. The end of the ceiling joist is checked out so as to rest on this fillet and come about $\frac{1}{2}$ inch below the binder. A strip of wood about $1\frac{1}{2}$ inches wide, and in the case illustrated $\frac{1}{2}$ inch thick, termed a **firring**, is nailed across the binder in a line with the ceiling joists. The laths when secured to this firring are thus kept a little below the binder, and a space is left for the plaster key.

The underside of a beam is sometimes nailed, to carry the plaster. This dispenses with the **firring** shown in fig. 130, while at the same time it becomes unnecessary to bring the ceiling joists below the binder. This economises space.

An alternative method is given which necessitates the cutting of a mortise on each side of the binder, thus reducing its strength.

As the ceiling joists have to be tenoned in after the binders are in position, the mortises must be formed as shown in fig. 131 and the joist brought sideways into its place. This is known as a **chase or pulley mortise.**

74. Framed floors.—Fig. 132 gives a section through



FIGS. 130 and 131.

part of a framed floor, showing the timbers employed in its construction, and also their disposition.

The only difference between this floor and that last described is that in the present case another set of timbers is introduced, viz. wooden girders.

These should be placed about 10 feet apart across the narrowest way of the room.

Into the girders are framed by means of tusk tenons the binders which carry the floor and ceiling joists.

The cutting of mortises in girders is very objectionable, the timber being considerably weakened by it.

An excellent plan is to support the ends of the binders in **iron stirrups** which are hung over the girder, and render mortising unnecessary (fig. 133).

In the absence of stirrups, the binders should be arranged

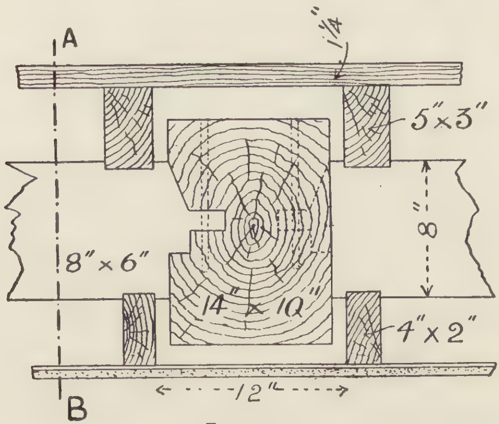
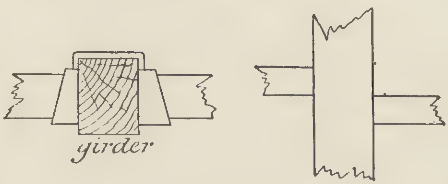


FIG. 132.

so that the mortises on one side of a girder do not come immediately opposite those on the other side.

The plan shown in fig. 134 explains this. The binders should also be placed so as not to necessitate cutting the girder in the middle of its length, which is its weakest point.



FIGS. 133 and 134.

75. Wooden girders.—In fig. 132 the girder shown is a simple beam of wood. The use of timber of such length and

scantling as is required for purposes of this kind is attended with several drawbacks.

The thorough seasoning of large balks of timber is a matter of considerable time and uncertainty.

Again, the strength is not uniform throughout the beam, that part which when growing was lowermost being more solid and durable.

Lastly, any defects or shakes are less likely to be discovered.

By dividing the balk longitudinally into two parts, or **flitches**, turning these with their sawn sides outwards, reversing

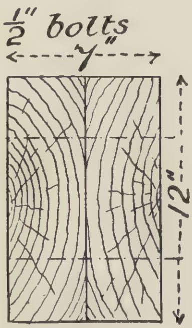


FIG. 135.

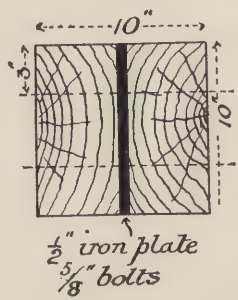


FIG. 136.

one of them and bolting the two together, the objections mentioned above may be removed.

A flitched girder of this description is shown in fig. 135.

When additional strength is required, an iron plate, the same in length and depth as the beam, may be inserted between the wood flitches.

This plate is also termed a **flitch**. Beams strengthened in this manner have been called '**sandwich beams.**'

Three or four planks are more frequently bolted together, the grain being reversed in the manner just alluded to. This is a cheap method of forming an exceptionally good beam, and is preferable to that shown in fig. 136, for the following reasons—(1) it dispenses with the use of an iron plate, thus avoiding the expansion and contraction to which that metal is subject when exposed to varying temperatures; (2) in case of fire the former

beam would become charred only, while the iron plate of the latter would twist the work to pieces.

76. Double floors with rolled iron joists as binders.—The double and framed floors previously described, in which timber binders and girders are used, are of comparatively rare occurrence nowadays.

Wood balks are being replaced by iron. The manufacture of rolled iron joists has arrived at such perfection, that they may now be obtained of all sizes and sections. For heavy work, two, three, four, and even a larger number of single iron joists may be united by means of plates and rivets, and thus formed into girders of any desired strength. Three examples of floors carried by these rolled iron joists are given.

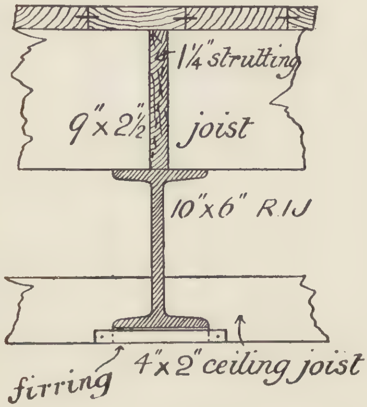


Fig. 137.

The section of a double floor shown in fig. 137 illustrates a very simple method of construction.

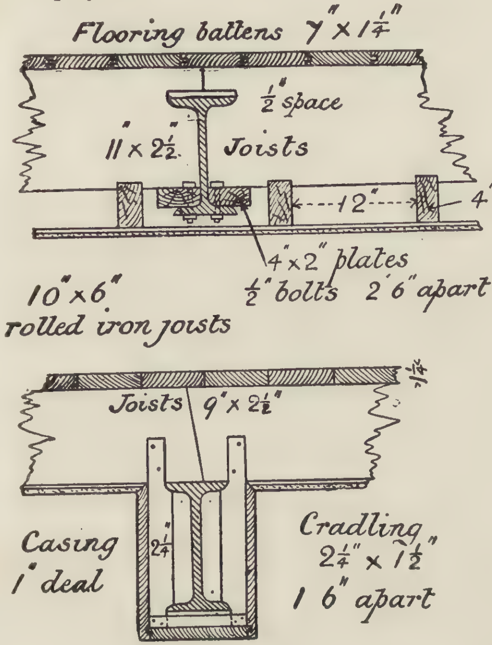
The bridging joists are merely laid edgewise on the upper flange of the rolled iron joist, or binder as we may term it. They cannot, however, be nailed down as in floors entirely of wood.

It is therefore highly necessary to stiffen the floor by strutting placed at frequent intervals. Solid strutting has been used in this case. The lower flange affords an easy means of carrying the ceiling joists. These are notched out so as to fit in the manner indicated. A firring nailed to the side of the ceiling joists assists in carrying the laths.

The rolled iron joists should be supported on **stone templates** and built securely into the wall.

It will be noticed that the floor just described and illustrated has a depth of about 22 inches. Where it is desirable to

lessen its thickness a method similar to that given in fig. 138 is often employed.



FIGS. 138 and 139.

Two wood plates 4 inches wide and 2 inches thick are bolted to the iron joist through the bottom flange. The practice of cutting holes in this part of an iron beam is, however, not to be advocated, although frequently adopted (see Chapter XI.) A much better plan would be to use plates of such thickness as to allow of bolting **through the web**, as in fig. 139 *a*.

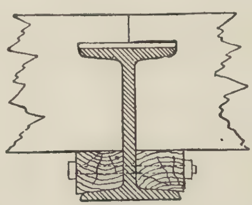


FIG. 139 *a*.

The bridging joists are checked out so as to fit the binder, and rest on the wood plates. By bringing them down in this way, the floor boards are kept a few inches above the top flange.

The $\frac{1}{2}$ inch space left above this flange is to allow for shrinkage in the depth of the joist.

In the example given, ceiling joists are carried by the bridging joists. This just brings the laths below the bottom flange. The total depth in the case including floor boards and ceiling is only 18 inches. When the depth of the rolled iron joists employed will allow of it, the ends of the wooden joists may be cut in between the flanges, projecting above and below them, the floor boards and ceiling being carried in the usual way.

Take, for instance, the case in which 8 × 6 (inches) rolled iron and 11 × $2\frac{1}{2}$ (inches) wood joists are employed.

By cutting the latter so as to rest on the bottom flanges of the former, and project $1\frac{1}{2}$ inches above and below, the use of wooden plates is avoided and the rolled iron joists left intact.

It is necessary in forming a floor of iron and wood, that the iron should have plenty of play against the joists, and also against the wall, to allow of expansion and contraction. The woodwork should therefore fit **loosely** between the iron joists and girders. Brickwork must never be built close up to the ends of the latter, but a space or pocket should be left for the reason stated above.

In some situations, such as school and warehouse floors, where the projection of a beam below the ceiling is not objectionable, the method illustrated in fig. 139 is often used. The strutting has been omitted in this case in order to show a bevelled joint between two bridging joists. The reason of its adoption is evident.

The rolled iron joists are hidden from view by a deal casing 1 inch thick carried on cradling secured to the wooden joists.

By cutting out the uprights, as indicated, the width of the casing is decreased, and at the same time its weight is partly thrown on the lower flange.

The boarding underneath is grooved and tongued into that at the sides.

The casing is sometimes secured to solid blocking, cut so as to fit in between, and project beyond the flanges.

77. Sound boarding and pugging. — A common

method of preventing the passage of sound through a floor is shown in fig. 140.

Fillets of rectangular or triangular section are nailed along the sides of the common joists from wall to wall. These fillets support rough boarding termed **sound boarding** cut $\frac{1}{2}$ inch less in width than the space between the joists ; on the sound boarding is sometimes spread a layer about 2 inches thick of a mixture of coarse stuff (rough mortar), sawdust, chopped straw, or hay, etc. This material goes by the name of **pugging.**

The practice of mixing with the pugging, substances belonging to the **vegetable** kingdom, has of late years been condemned as being a means of causing disease, rot, etc. It is

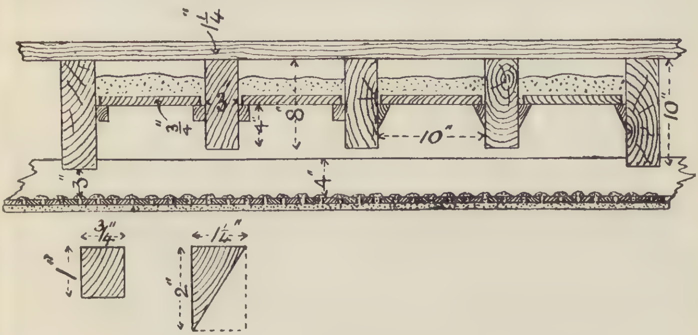


FIG. 140.

therefore a matter of great importance that all materials mixed with the mortar should be of a **mineral** nature.

Silicate cotton, known also as **slag-wool,** manufactured from a by-product of iron smelting, is coming largely into use for this purpose. It is spread in a layer about one inch thick and is a very excellent non-conductor of heat and sound.

This is due, not so much to any property of the material itself, as to the quantity of air occupying the interstices between the fibres of which it is composed.

The use of pugging being to intercept sound, it is hardly necessary to add that it must be kept from contact with the underside of the floor boards.

78. Floor boards.—The side joints in common use for

floor boards may be plain or butt, rebated and filleted, ploughed and tongued, grooved and tongued, grooved, tongued, and rebated, and dowelled.

These have already been explained and illustrated in Chapter IV. It was also pointed out that all grooves, rebates, etc., should be nearer the lower than the upper surface of the boards in order that as much wear may be obtained from them as possible.

79. Heading or end joints.—The joints formed in laying floor boards end to end are termed heading joints.

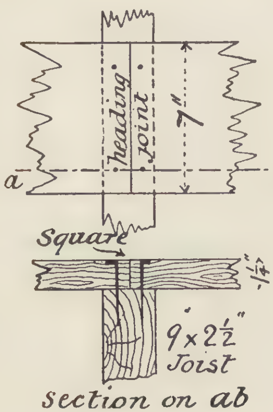
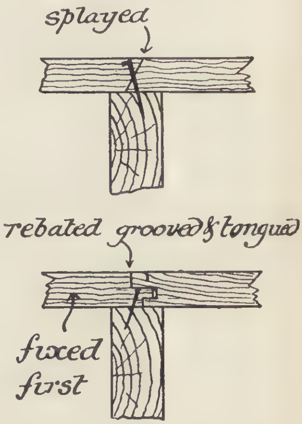


Fig. 141.



Figs. 142 and 143.

These may be worked in the same way as the side joints already referred to.

80. Square or butt heading.—An example in plan and section showing the method of nailing is shown in fig. 141.

The boards are cut square and the ends are simply butted together.

81. Bevelled heading.—This joint is formed by splaying back, or bevelling, the ends of the boards. Only two nails are required for securing the joint if used in the manner indicated.

82. Rebated, grooved, and tongued heading.—Fig. 143 is an example of this. The tongued end is first nailed down and then the other is slipped into its place.

When the nail heads do not appear at the surface the boards are said to be **secret nailed.**

83. Laying floor boards.—For good work the boards should be carefully gauged to the same width, so that when laid the side joints may run in unbroken lines along the floor. When this is the case they are said to be **straight jointed.**

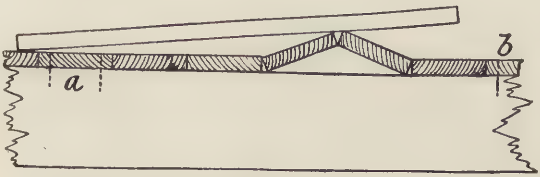


FIG. 144.

The heading joints, however, should not be in continuous lines.

In work of this description the boards are laid in position and forced tightly home with the assistance of a floor cramp before being nailed down.

For common floors the following practice is frequently adopted.

Two boards *a* and *b*, fig. 144, are nailed down at a distance apart rather less than the width of four or five boards, in this case four. The intervening boards are then placed in position and forced home by jumping on a plank laid across them. This method is termed '**folding**,' and can only be adopted when the side and end joints are square.

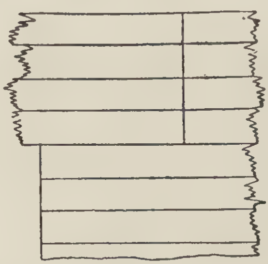


FIG. 145.

The boards laid at one time are all of the same length. The result is that continuous heading joints are formed, as shown in fig. 145.

Exercises on Chapter V.

1. Draw the plan of a single floor shown in fig. 121 to a scale of $\frac{3}{4}''$ to a foot.

2. Draw to a scale of $\frac{1}{4}$ the method of supporting the end of a common joist given in fig. 122.

3. Two sections taken at different points of a single floor are shown in figs. 123 and 124. Draw to a scale of $\frac{1}{6}$.

4. Draw the arrangement of trimmer, trimmer arch, and hearth shown in fig. 125 to a scale of 2″ to one foot.

5. Elevation and section of common joists, sleeper, and dwarf wall, fig. 127. Draw to a scale of $\frac{1}{6}$, showing the wall 18″ high above the footings.

6. Plan of part of a double floor, fig. 128. Draw to a scale of $\frac{1}{24}$.

7. Fig. 129 shows a section on the line *c d*, fig. 128. Draw to a scale of $\frac{1}{6}$.

8. Two methods are shown of securing ceiling joists between binders in a double floor, fig. 130. Draw these to a scale of 2″ to a foot, showing a plaster ceiling in each case.

9. Section through the wooden girder of a framed floor, fig. 132. Draw to a scale of $\frac{1}{6}$ and give its plan, the floor boards being removed.

10. Draw to the same scale a section on the line A B, fig. 132.

11. Draw the sections given in figs. 135 and 136 to a scale of $\frac{1}{6}$, showing the bolts placed chequerwise 12″ apart.

12. Fig. 137 is a section of a double floor carried by rolled iron joists. Draw to a scale of $\frac{1}{4}$, adding a plaster ceiling. Show also a plan to the same scale, the floor boards being removed. The common joists are 12″ and the ceiling joists 14″ apart from centre to centre.

13. Figs. 138 and 139 show sections of floors differently arranged from that last mentioned. Draw the views given to a scale of 2″ to a foot.

14. Section through joists showing sound boarding, and pugging, fig. 140. Draw $\frac{1}{4}$ full size.

15. Draw to a scale of $\frac{1}{4}$ the sections of heading joints shown in figs. 141, 142, and 143.

16. Section of a single floor, fig. 146 (*a*). Draw to a scale of $\frac{3}{4}''$ to a foot, showing ceiling joists, sound boarding, and pugging.

17. Cross section through floor joists, fig. 146 (*b*). Draw to a scale of $\frac{1}{12}$, adding $1\frac{1}{2}''$ floor boards, plaster pugging, and a lath and plaster ceiling.

18. Section through a 14″ brick wall, showing the bricks corbelled out to carry the ends of the floor joists, fig. 146 (*c*). Draw to a scale of $1\frac{1}{2}''$ to 1′, showing the bricks laid in English bond, and a joist 9″ deep resting on a $4\frac{1}{2}'' \times 3''$ plate.

19. Plan of a floor in which the girders are rolled iron joists $10'' \times 4\frac{1}{2}''$ and the binders of wood $9'' \times 6''$ resting on the top of the girders, and carrying $6'' \times 3''$ bridging joists, and $1\frac{1}{2}''$ floor boards 7″ wide, fig. 146 (*d*). Give a section to a scale of $\frac{1}{24}$ through A A, showing the construction.

20. Plan of a trimmer running into a trimming joist, fig. 146 (*e*). Give a vertical section through A B $\frac{1}{4}$ full size, showing how one would be tenoned into the other.

21. Plan of a first-floor passage, fig. 146 (*f*). Draw to a scale of 4′ to an inch, showing the floor joists by single lines, with a well hole 12′ × 3′ 6″ for the stairs. Write their names against the different parts.

22. Plan of a fireplace in the long side of a room, fig. 146 (*g*). Draw it to a scale of $\frac{1}{2}''$ to a foot, adding trimming joists $10'' \times 2\frac{1}{2}''$, trimmer $10'' \times 3''$, and trimmed joists $10'' \times 2''$. Figure the scantlings on the different parts.

23. Plan of a double floor, showing position of girders, fig. 147 (*a*).

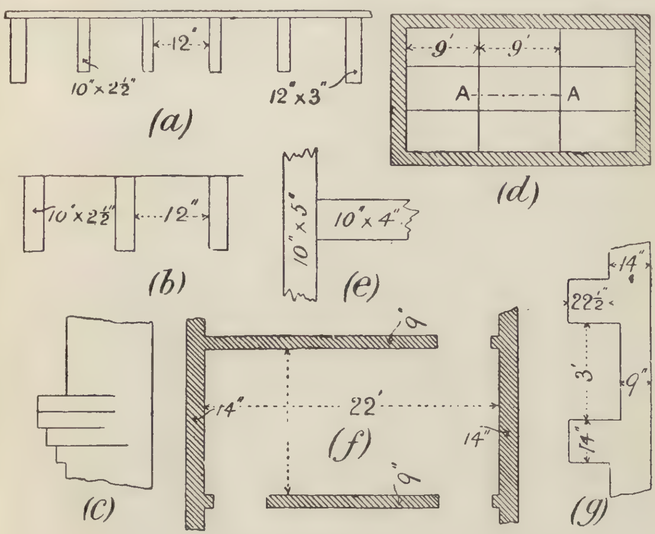


Fig. 146.

Give a section through A A to a scale of $\frac{3}{4}''$ to a foot showing rolled iron girders $5'' \times 10''$, bridging joists $8'' \times 2\frac{1}{2}''$, floor battens $7'' \times 1\frac{1}{2}''$, and ceiling joists $4'' \times 2''$.

24. Plan of an upper room to be floored with a single floor, the dimensions of timbers being as follow: Common joists $9'' \times 2\frac{1}{4}''$, trimming joists $9'' \times 2\frac{3}{4}''$, trimmer $9'' \times 2\frac{3}{4}''$, herring-bone struts $2'' \times 1\frac{1}{2}''$, fig. 147 (*b*). Draw the plan of the floor to a scale of 4′ to an inch and give a section on A B to a scale of 1″ to 1′, showing the trimmer arch and herring-bone strutting.

25. Plan of a room, fig. 147 (*c*). Draw to a scale of $\frac{1}{24}$ the portion

marked A, showing the hearthstone, and a wooden floor laid in batten widths.

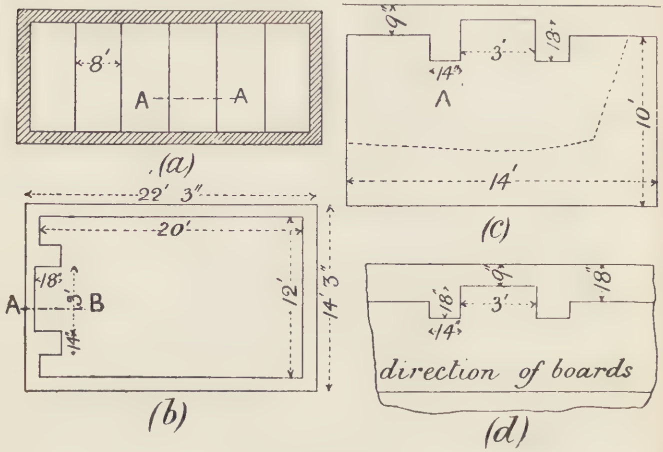


FIG. 147.

26. Plan of part of a first-floor room, fig. 147 (*d*). Draw to a scale of 5′ to an inch, filling in the timbers carrying the floor, and writing their names and approximate scantling on them, supposing the room to be 14′ wide.

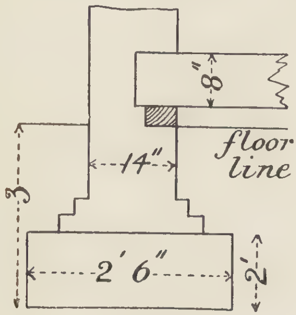


FIG. 148.

27. Section at the base of the wall of a dwelling house, fig. 148. Draw to a scale of $\frac{1}{24}$, making any alterations you may consider desirable. State your reasons for any alterations you make.

28. Part of the plan of a ground-floor room, fig. 149 (*a*). Give a section to a scale of $\frac{1}{24}$ through A B, showing a $2\frac{1}{2}''$ front hearth carried on a 9″ brick wall, and 6″ × 2″ joists supported at the centre on a 9″ sleeper wall, there being 1′ clear between the ground and the underside of joists.

29. Plan of part of an upper floor, showing a fireplace, fig. 149 (*b*). Draw to a scale of $\frac{3}{4}''$ to a foot a vertical section through A B, showing a trimming joist 9″ × 3″, common joists 9″ × 2″, floor boards $1\frac{1}{2}''$, front hearth 3″, back hearth 2″, and a half brick trimmer arch.

30. Plan of and section through a chimney breast in the first floor of a house without a basement, fig. 149 (*c*). Draw to a scale of 2′ to an inch and

add the floor timbers in the space marked on the plan by the dotted lines, the timbers having the following dimensions: Trimming joists $10\frac{3}{4}'' \times 3''$, trimmer $10\frac{3}{4}'' \times 3''$, common joists $10\frac{3}{4}'' \times 2\frac{1}{4}''$, wall plates $4\frac{1}{2}'' \times 3''$. Show also the hearths and trimmer arch, and write the names of the joists on them.

31. Show by means of a plan and section what is meant by floor boards laid folding, with broken joints.

32. Draw to a scale of $\frac{1}{6}$th, sections of the following floor coverings: (*a*) $1\frac{1}{2}''$ rebated and filleted floor, deal widths; (*b*) $1\frac{1}{4}''$ ploughed and tongued floor, batten widths; (*c*) $1\frac{1}{4}''$ deal floor laid folding.

33. Give a cross section to a scale of $1''$ to a foot through a portion of

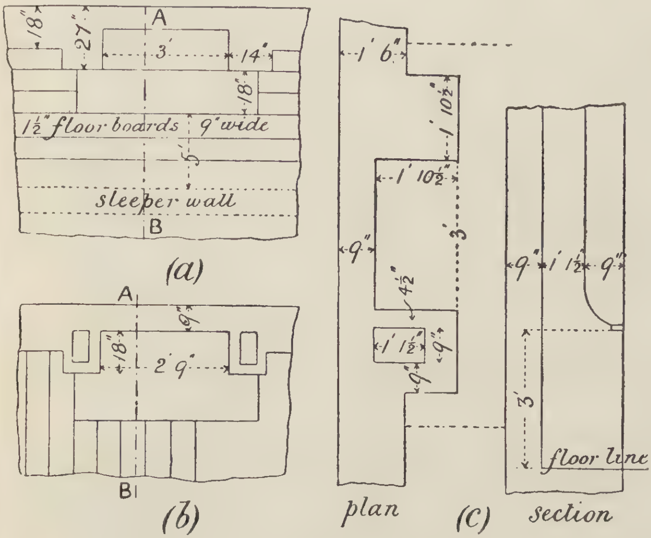


Fig. 149.

a single floor, showing about four joists $10'' \times 2\frac{1}{2}''$ and the method of stiffening them by means of herring-bone struts.

34. Give sketches showing the difference between a double floor with rolled girders and a floor consisting of rolled girders, binders, and bridging joists.

35. Give a cross section to a scale of $2'$ to an inch of a double floor, taking the following scantlings: Girders $10'' \times 12''$ and $18'$ clear span, bridging joists $7'' \times 2''$, ceiling joists $3\frac{1}{2}'' \times 2''$. Half the span will be sufficient.

36. Show by sketches the difference between single, double, and framed floors, giving the names of the different parts.

37. Draw to a scale of 2′ to one inch a plan of part of an 18″ wall, showing a chimney breast 6′ 6″ wide projecting 14″, with a 3′ 6″ fire opening 18″ deep. Supposing the floor joists to run at right angles to the chimney breasts, show how they would be trimmed round it, the common joists being $2\frac{1}{4}''$ wide and the trimmer and trimming joists $3\frac{1}{2}''$ wide.

38. The dimensions of the timbers and boarding for a double floor over a room 30′ long and 17′ broad, ceiled on the under side, are as follows: Girders $14'' \times 11''$, bridging joists $8'' \times 2\frac{1}{2}''$, ceiling joists $5'' \times 2''$, flooring boards, batten widths $1\frac{1}{2}''$ thick, ploughed and tongued. The plan of the room with the position of the girders is shown. Give to a scale of $\frac{1}{24}$ a sectional elevation on G H; also give rough hand sketches of joints.

39. Draw to a scale of $\frac{3}{4}''$ to one foot a longitudinal section through a wooden double floor. Show two girders $12'' \times 8''$ and 8′ apart, bridging joists 7″ deep carried between the girders on $4'' \times 1\frac{1}{2}''$ fillets spiked to their sides; also $4'' \times 2''$ ceiling joists below the girders.

40. Draw to a scale of 4′ to an inch the plan of about 20′ of a passage 8′ wide, showing the naked floor with a well hole for the stairs 3′ 6″ wide and 15′ long, the joists to be $11'' \times 2''$ and spaced 12″ apart in the clear; the trimmer to be $11'' \times 3''$. Give enlarged drawings showing the mode of connecting the joists to the trimmer and the trimmer to the trimming joists.

CHAPTER VI.

PARTITIONS.

84. General remarks.—The term **partition** is applied in carpentry to the timber framework covered with lath and plaster, or match-boarding, used in place of a wall to separate one room from another.

They are used chiefly for **upper** floors where brick walls cannot be employed. The great weight of brickwork precludes its use for dividing rooms from each other, unless it is carried up quite from the ground. This of course is not always possible.

A **partition** may be supported in various ways. It may be **hung** from the floor above, or **rest** on that beneath. This last method should never be used.

The weight of the partition, often considerable, is liable to deflect the joists and fracture the ceiling underneath.

A common way is to support it on a party wall running beneath.

In the examples shown in this chapter each partition is a framed and braced structure, with its ends supported on **wall**

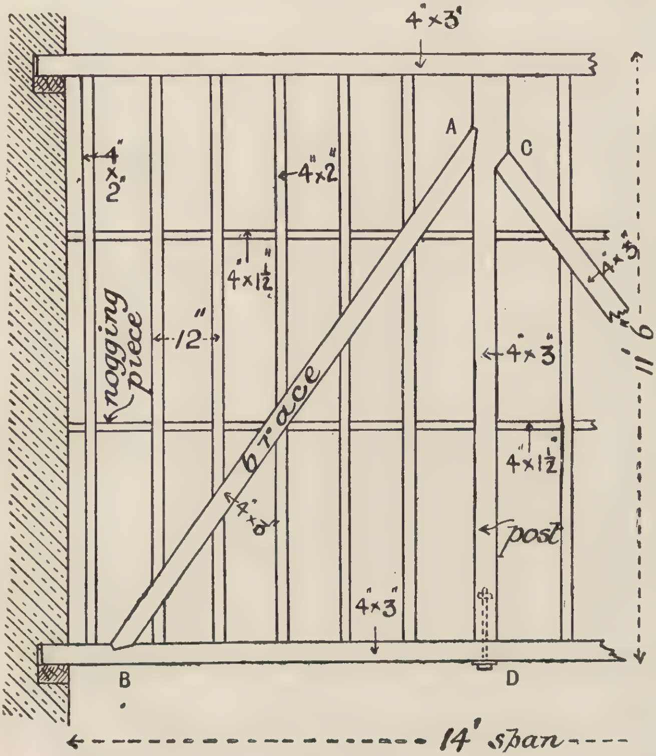


Fig. 150.

plates or **stone templates** built into the wall or carried on corbels.

By this means the weight is transmitted directly to the main walls of the house. This **self-supporting** system is by far the best.

When partitions are supported uniformly from below, the addition of struts or braces becomes unnecessary. We have in this case the simplest form of partition. The trussed partitions illustrated are of use in assisting to support the floors above.

Structures of this kind are very liable to settle. Care must be taken, therefore, in fitting the joints to leave them a little

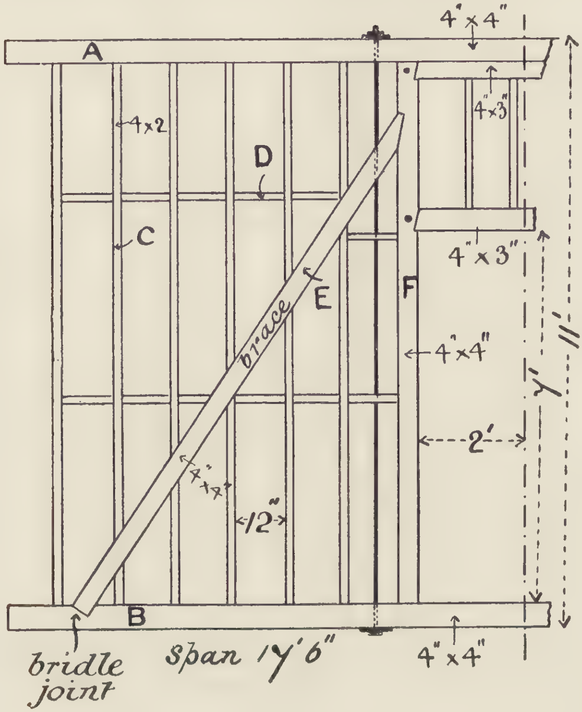


FIG. 151.

slack at certain points, so that when the settlement does take place, and the timbers assume their final position, the pressure may be evenly distributed over the bearing surfaces. For the same reason it is well to delay the plastering as long as possible.

Partitions may be classified as follows :—

(1) Common partitions.

(2) **Trussed partitions.**

(3) **Bricknogged partitions.**

85. Common partition.—This, as before remarked, is not trussed ; it consists of two horizontal members, the top one called a **head**, the lower one a **sill.** This latter is supported in the manner already described. Between the head and sill are fixed a number of vertical pieces known as **quarters** or **studs,** stiffened at intervals by horizontal struts or **nogging pieces,** which are nailed to the studs in continuous lines at vertical distances apart of about 4 feet. The studs are inserted to carry the laths for the plaster covering, and should be placed about 12 inches apart from centre to centre.

An example of this simple kind of partition has not been given, but reference to the forms illustrated will enable the student to follow the description given above.

86. Trussed partition.—Fig. 150 illustrates the framework of a partition trussed in order to throw its weight on the walls. In this case there is no door opening.

The system of framing here adopted is the same in principle as that of the king post roof (see Chapter VII.). The post is framed into the head and sill by stub tenons, a $\frac{3}{4}$ inch bolt passing through the sill and into the post in order to keep the pieces well together. There are several ways of framing together the braces and other members.

At A and B ordinary oblique tenons are shown ; that at B may be secured by a strap or bolt (see Chapter IV. and fig. 155).

At C a plain mitre joint is used bisecting the angle. This method is not so economical as that first mentioned. A great deal of material has to be checked out to provide an abutment for the brace. The studs are stub tenoned into the head and sill and well nailed to the braces, against which they butt obliquely.

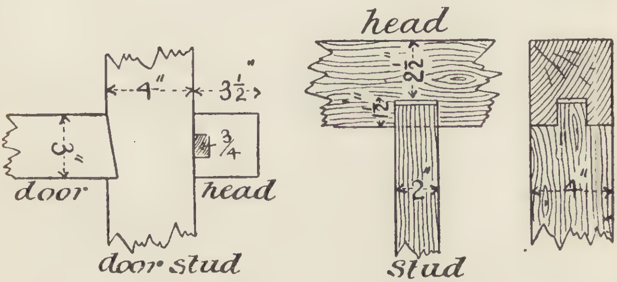
In order to render such a partition **sound proof,** a good plan is to nail canvas or felt over the studs on both sides, and fill in the spaces with **silicate cotton,** a material already referred to as **sound proof, fire proof,** and **vermin proof.** The laths cannot be fastened on this covering, as it would

H 2

interrupt the key required for the plaster. Strips of wood about $1\frac{1}{2}$ inch wide and 1 inch thick must therefore be nailed to the studs over the felt or canvas; to these the laths may be affixed in the usual way. In cases where the plaster is not considered necessary, it may be omitted, the wall paper, if used, being hung on the canvas itself.

A modification of the last-mentioned form of trussed partition is shown in fig. 151.

A space is left in the framework for a central door. The posts F are known as **door studs.** At the foot of the brace E is shown a bridle joint. The tendency of the braces, when subjected to a downward strain, is to force inwards the door



FIGS. 152 and 153.

studs. This is counteracted partly by the **doorhead,** and partly by the **straining beam** above. The doorhead is housed into the posts. By this means the tenon is not required to sustain the whole weight thrown on the doorhead. Similar joints are used for the straining beam.

A $\frac{3}{4}$ inch bolt on each side of the doorway is added to tighten up the joints and render the partition rigid.

Fig. 152 shows a doorhead tenoned quite through the post and secured by a pin or wedge on the other side. This is sometimes adopted in place of the stump tenon used in the last example.

Two vertical sections taken through the junction between a stud and the head of a partition are given in fig. 153.

A framed partition with an ordinary doorway at the side is given in fig. 154. Wrought-iron straps are used to secure the joints between two of the posts and the sill. The outer posts,

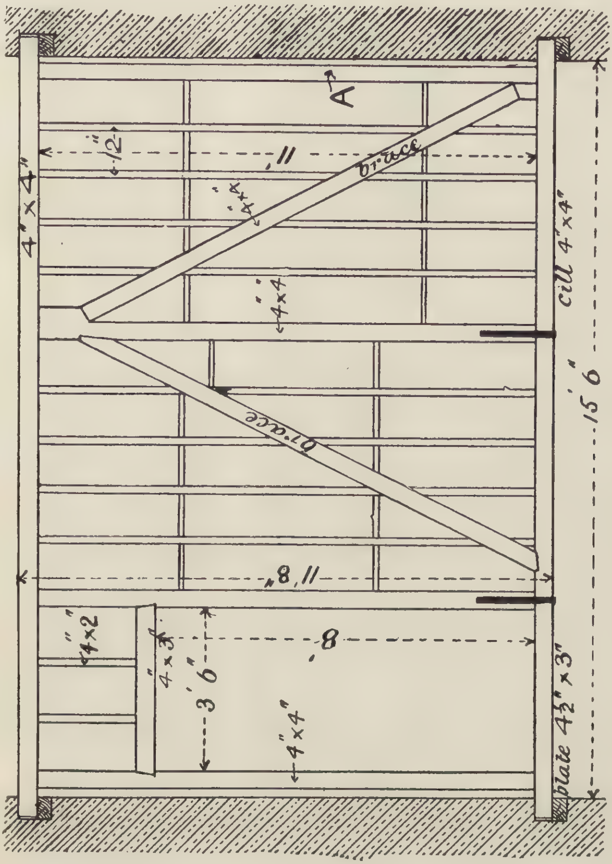


FIG. 154.

being so near the points of support, do not require these. An alternative method of framing in the braces is shown. Instead of checking out the post × to secure an abutment for the lower

end of the brace, a block is shown bolted to the post for the same purpose.

A trussed partition with side door spaces suitable for carrying the floor above is illustrated in fig. 155.

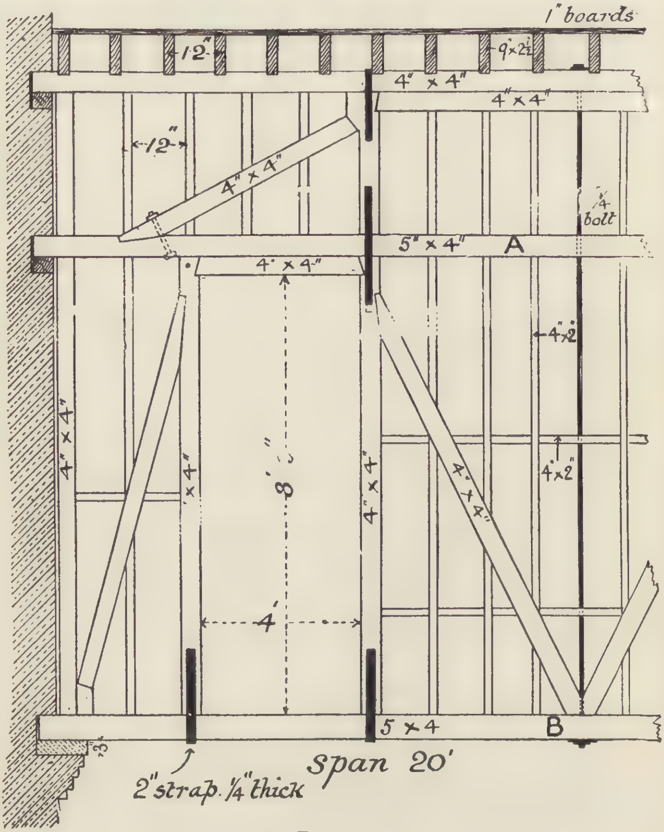


Fig. 155.

This partition may be said to consist of two distinct portions separated by the cross timber or **intertie** A, each of which is trussed in a different manner. The part above the horizontal beam A resembles the queen post truss given in Chapter VII.

Had a wooden post been used in place of the iron bolt, the braces in the part referred to might have been carried to its head, so as to resemble a king post truss. The bolt affords an easy means of tightening up the joints of the framework.

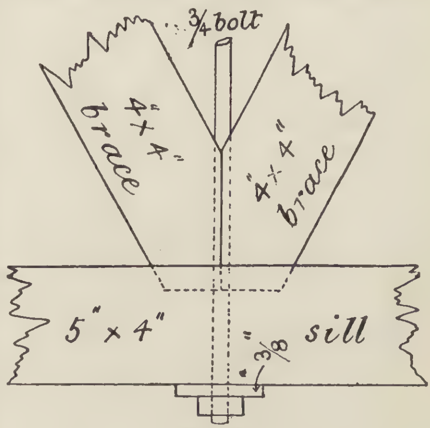


Fig. 156.

A detail of the joint at B is given in fig. 156. The lower ends of the braces are bevelled off in order to butt together as in the figure. Stub tenons are then cut at the ends to fit a mortise in the sill; a ¾ inch bolt passing through this joint to the partition head is tightened up either from above or below, wrought-iron washers being interposed to protect the fibres of the wood from injury.

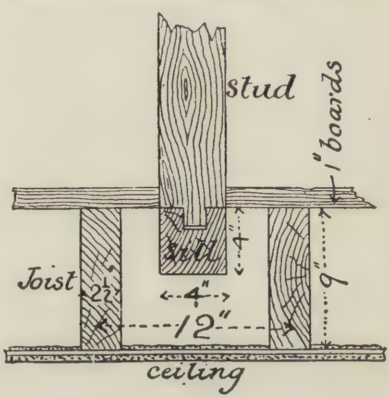


Fig. 157.

In the case of partitions with door openings, it is necessary to arrange the sill so that it does not interrupt the passage between one room and the other. It would be exceedingly inconvenient to have the sill projecting 2 or 3 inches above the floor boards across the opening. This may be avoided in several ways.

In fig. 157 it will be seen that the partition sill runs across the room in the same direction as the floor joists. It may therefore be kept below, or

level with, the upper edges of the joists throughout its length. In this way no portion will appear above the floor boarding.

This method, however, cannot be adopted when the joists and sill run in different directions. In fig. 158, the sill having to cross the joists must be dispensed with in the door opening. The door posts are, therefore, continued below the sill, their lower ends being supported by cross pieces either framed in between the joists, or supported on fillets of wood nailed to them.

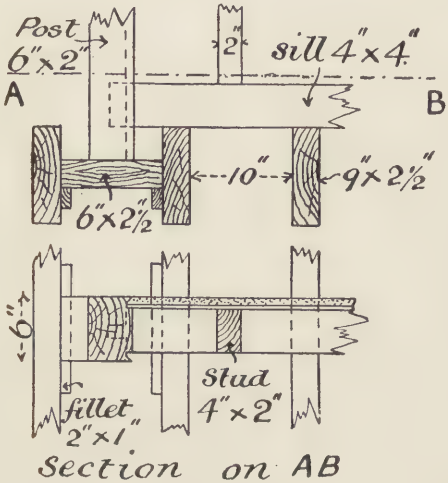


FIG. 158.

The sill is cut away at the door opening, and each piece is housed and stub tenoned into the door post as shown in the figure. In all the preceding examples of partitions it will be noted that the quarters or studs are the same depth, viz. 4 inches, as the door posts, braces, etc. In these cases separate door frames must be inserted, so as to stand out at least an inch beyond each face of the partition framework. The laths and plaster will then bring up the thickness to 6 inches, flush with the door frames.

When it is desirable to hang the door to the post itself, the latter must be 6 inches deep, as shown in fig. 158. Splayed rebates, run along the back edges of the post, receive the ends of the laths and afford a key for the plaster. In the plan, fig. 158, one side of the partition only is shown plastered.

87. **Bricknogged partitions.**—In these the timber frame is filled in with brickwork. The bricks may be arranged on edge or in the usual manner. The first method gives a thickness of

about 3 inches, the second $4\frac{1}{2}$ inches or thereabouts, exclusive of the plastering.

The quarterings must be inserted at such distances apart as will allow of 3, 4, or 5 **whole bricks** being laid between them, in order to avoid unnecessary cutting.

Exercises on Chapter VI.

1. Part of the framework of a quartered partition, fig. 150. Draw an elevation of the complete partition to a scale of $\frac{1}{2}''$ to one foot. Give details of the joints B, C, and D.

2. Draw complete the framed partition shown in fig. 151. It is to rest on $4\frac{1}{2}'' \times 3''$ wall plates carried on brick corbelling. Give a detail drawing of the joint at B. Scale $\frac{1}{24}$.

3. Draw the details shown in figs. 152 and 153 to a scale of $\frac{1}{3}$. Add a plan of the first of these.

4. Draw to a scale of $\frac{1}{24}$ the partition shown in fig. 154. Add a horizontal section 5 feet above the upper side of the sill.

5. Show a complete elevation of the partition given in fig. 155. Scale $1''$ to $2'$. Draw also a vertical section through the centre of the door space.

6. Draw the detail given in fig. 156 to a scale of $\frac{1}{4}$. Add a vertical cross section taken through the centre of the bolt.

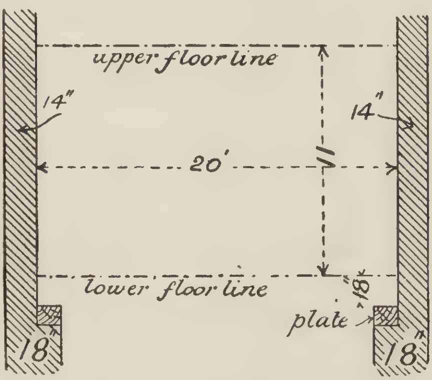


Fig. 159.

7. Section through a floor showing a partition sill carried across the room between the joists, fig. 157. Draw to a scale of $3''$ to one foot the view given. Add a plan, the floor boards being removed.

8. Draw fig. 158 to a scale of $1\frac{1}{2}''$ to one foot.

9. Section through a house in which a 4″ trussed partition is to be fixed to carry a floor on its head, the partition to have a door about 7′ × 3′ in the centre. Fig. 159. Draw the partition in elevation to a scale of 1″ to 4′, showing any ironwork that may be necessary; the

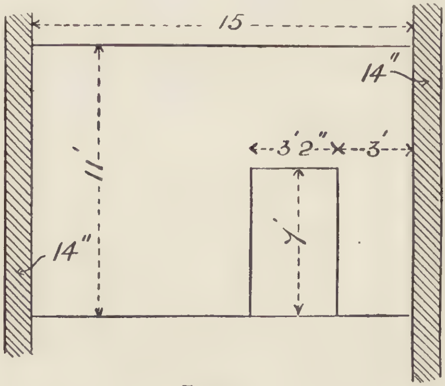


FIG. 160.

timbers forming the truss to be 4″ × 4″, the quartering for filling to be 4″ × 2″.

10. A cross section of a room showing a doorway in a quartered

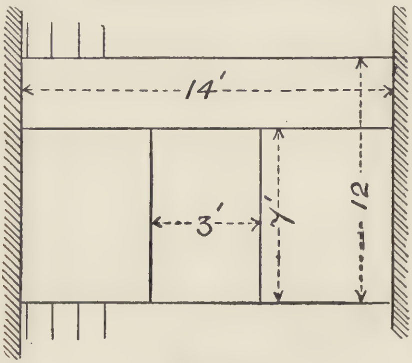


FIG. 161.

partition, fig. 160. Draw to a scale of 1″ to 4′ an elevation of the timber truss from the following dimensions: Head and sill 5″ × 4″, door studs 4″ × 4″, quarterings 4″ × 2″, braces 4″ × 3″. Show how it is supported.

11. A skeleton diagram of a trussed partition which helps to carry the floors above and below, fig. 161. Draw to a scale of $\frac{1}{30}$ an elevation of one half the partition, filling in all the necessary details. Show the use of

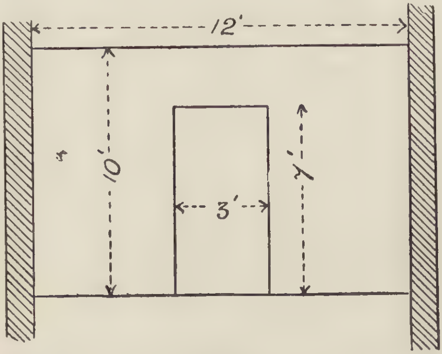


FIG. 162.

nogging pieces. The scantlings of the members are as follows: Sill 10″ × 4″, head 6″ × 4″, studs 4″ × 2″, braces 4″ × 4″, door-studs 4″ × 4″.

12. Section of a room showing a doorway in a lath and plaster framed partition, fig. 162. Draw to a scale of $\frac{1}{24}$ an elevation of half the partition, taking the following dimensions: Head and sill 4″ × 3″, door studs

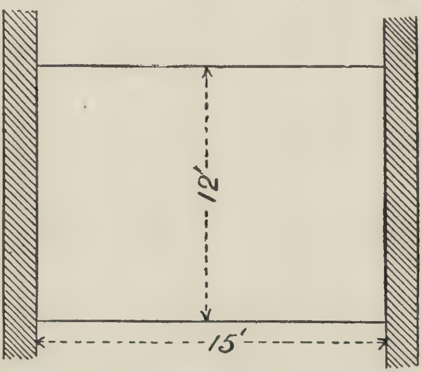


FIG. 163.

4″ × 4″, studs 4″ × 2″, braces 4″ × 3″, the partition to stand independent of the floors.

13. An outline diagram of a quarter partition which has to assist in carrying a floor above, fig. 163. Draw to scale of 1″ to 3′, supplying any

details you may consider necessary, and mark the names and scantlings of the different members.

14. Outline of a lath and plaster framed partition, fig. 164. Draw to a scale of $\frac{1}{24}$ an elevation, taking the following scantlings: Head and sill $4'' \times 4''$, door studs $4'' \times 4''$, quarters $4'' \times 2''$, braces $4'' \times 3''$, the partition to rest on brick corbels.

15. A room $14'$ wide is to be divided in two by a quarter partition. It is to rest on $4\frac{1}{2}'' \times 3''$ plates which carry the floor joists on brick offsets. Give to a scale of an inch to $2'$ an elevation of the framing of the

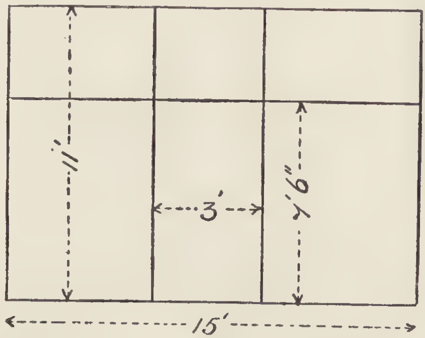


FIG. 164.

partition, showing a central opening $7' \times 3'$ for a door. The scantlings, which are to be marked on the different members, are to be as follows: Sills $4'' \times 4''$, studs or quarters $4'' \times 2''$, braces $4'' \times 2''$, door studs $4'' \times 3''$.

16. The scantlings of a framed partition carried on two $14''$ brick walls $15'$ apart, with a $3'$ doorway in the centre, are as follows: Sills $4'' \times 3''$, studs $4'' \times 2''$, door studs $4'' \times 4''$, braces $4'' \times 2''$. Give an elevation of half the partition to a scale of $2'$ to an inch, marking the scantlings on the different parts, the bottom sill to rest on stone corbels and the top sill to run into the walls.

CHAPTER VII.

WOOD ROOFS.

88. General remarks.—In carpentry, the term **roof** is applied to the **timber framework** which supports the covering of a building.

There are numerous methods of arranging this framework. In devising the form of roof best adapted to any particular building, consideration must be given, first of all, to the space it has to bridge across. This space is known as the **span.**

The term **pitch** will be found of frequent use in this chapter. It is applied to the **amount of slope** given to the sides of a roof. This inclination to the horizontal may be given in two ways: (1) By the number of degrees in the angle which the roof makes with the horizon, and (2) by the ratio which the **height or rise** of the roof, measured from the springing line to the uppermost point, bears to the span.

The following table shows the relation between these two methods of indicating the slope of a roof:—

Angle of inclination to the horizontal	Ratio of rise to span
18° 25′	$\frac{1}{6}$
26° 35′	$\frac{1}{4}$
33° 42′	$\frac{1}{3}$
45° 0′	$\frac{1}{2}$
53° 0′	$\frac{2}{3}$
56° 20′	$\frac{3}{4}$
63° 30′	1

The correct pitch for a roof is determined to a large extent by the **nature of the covering.** This consists usually of **slates, tiles,** or **sheet metal,** such as lead, zinc, or copper. When metal is used, the roof may be almost flat. Slates and tiles, in order to throw off the water, and also to be impervious to the weather, must be laid at an angle of about $26\frac{1}{2}°$ at the least.

It will be easily understood that the steeper the pitch the more quickly are rain and snow got rid of, and the less likely will they be to penetrate between the slates or tiles. There is also less probability of the covering being stripped off by the wind.

89. Forms of roofs.—Fig. 165 exhibits several styles of roofing, arranged so as to show a somewhat progressive development.

The following names are given to them :—

(1) **Lean-to or pent roof**	. . . .	Fig. 165 (*a*)
(2) **V-roof**	. . . .	„ (*b*)
(3) **Couple** or **span roof**	. . . .	„ (*c*)
(4) **Couple close** or **span close roof**	.	„ (*d*)
(5) **Collar roof**	. . . . . .	„ (*e*)
(6) **King post roof**	. . . . .	„ (*f*)
(7) **Queen post roof**	. . . . .	„ (*g*)
(8) **Flat-topped roof**	. . . . .	„ (*h*)
(9) **Curb or Mansard roof**	. . . .	„ (*i*)

The ends of any of these roofs may be finished in two ways.

Fig. 165 (*k*) shows the plan and elevation in a case where the roof is terminated by a slope. It is then said to be **hipped.**

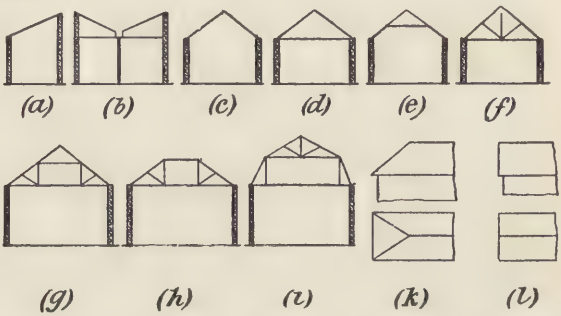


Fig. 165.

The angles formed at the intersection of the sides and end are termed **hips.**

A **pavilion** roof is one hipped at both ends.

A **gabled** roof is finished off vertically at the end, fig. 165 (*l*).

The student is not required, in the elementary course of building construction laid down by the Science and Art Department, to consider the more complicated methods of roofing. It has been thought advisable, however, to overstep the limits, and include in these notes a short description of the queen post roof in addition to those specified.

90. Lean-to roof.—This has only one slope, and consists of a row of timbers arranged in an inclined plane against a vertical wall. Fig. 166 shows a section through a roof of this description. The timbers crossing from one wall to the other at an angle of 30° are called **principal rafters.** The upper ends of these are notched out, or **birdsmouthed,** so as to fit on a wall plate carried by brick corbelling. The lower ends are also cut to fit the plate laid along the inner side of the wall. The length of the rafters in this instance being considerable, they require support at some intermediate point. This is afforded by a **strut,** the foot of which is secured to a

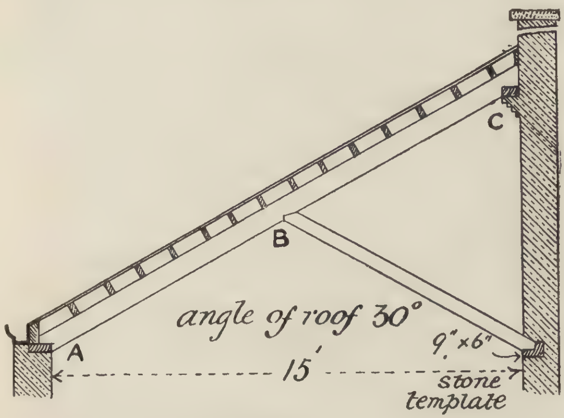


FIG. 166.

template built into the wall, the other end being housed and tenoned into the rafter in the middle of its length (fig. 168).

Across the principal rafters, and notched to them, are placed others of lighter scantling, running in a horizontal direction, known as **common rafters.** In practice it is common to place these 12 inches apart in the clear, i.e. with a 12 inch space between adjacent rafters. **Roof boarding** is then nailed on the common rafters to carry the slates or tiles.

The method of construction illustrated in the preceding figures is somewhat unusual for **lean-to** roofs. The span is, as a rule, very small, and does not necessitate the use of struts.

The extra set of rafters is also generally dispensed with, the roof boards being nailed directly to the timbers crossing from wall to wall.

91. A V-roof may be styled a **double lean-to**, the slopes inclining from the main walls towards a gutter in the centre of the building. This gutter is usually carried by a party wall. In fig. 165 (*b*), iron columns or wood posts are used for the same purpose.

92. A couple roof is one in which the rafters are simply placed in an inclined position, running from wall plate to ridge

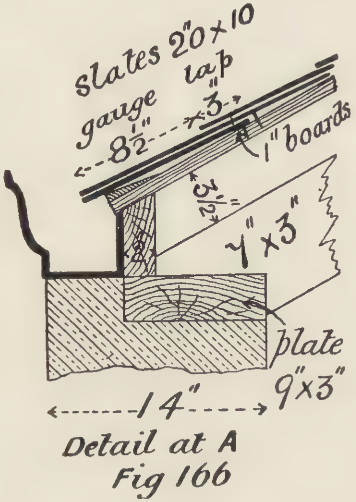


Fig. 167.

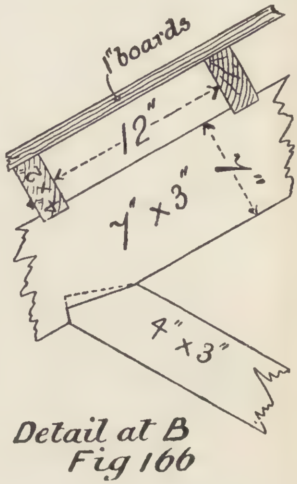


Fig. 168.

board, fig. 165 (*c*). There is no cross-piece to tie in the rafters and prevent the lower ends from spreading outwards. This being the tendency, couple roofs should not be adopted where the span exceeds 12 feet, unless the walls are of exceptional thickness.

Fig. 174 may be taken as an illustration of the way in which the lower ends of the rafters are secured to the wall plates. In this case the plate is laid along the inner edge of the wall, and the rafter foot notched out to fit on it. Nails are used to

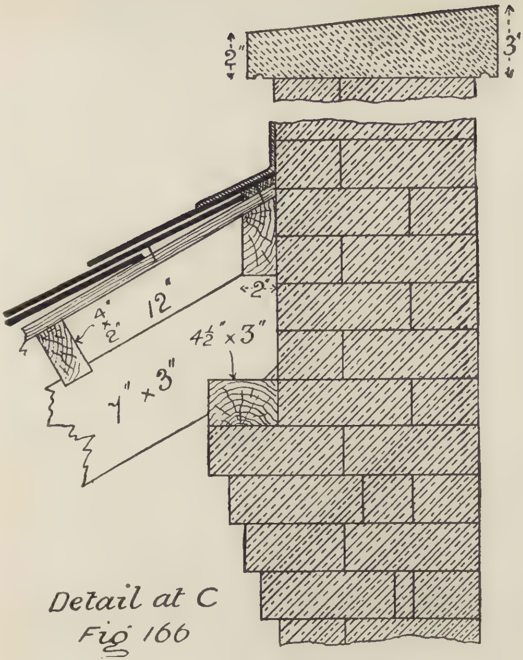


Fig. 169.

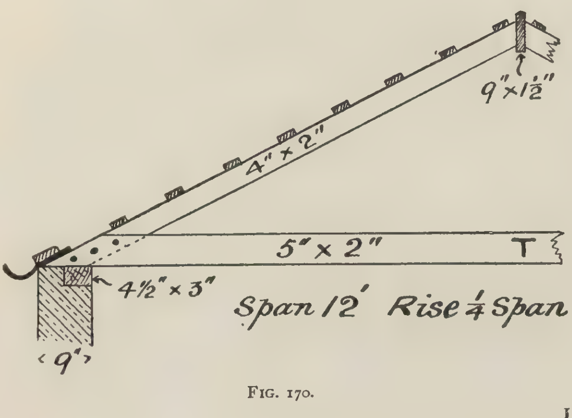


Fig. 170.

secure them. The **ridge board** runs along the apex of the roof, parallel to the walls. The rafters are fastened to it by nailing (fig. 170).

93. Couple close roof.—The defect alluded to in the preceding construction is removed by inserting a **tie beam** T (fig. 170). An iron rod may also be used for the same purpose.

The tie, when more than 12 feet in length, should be supported in the centre by a light iron rod or **kingbolt** hung from the ridge board.

Fig. 171 shows the joint between rafter and tie beam, roof boarding being used instead of slate battens.

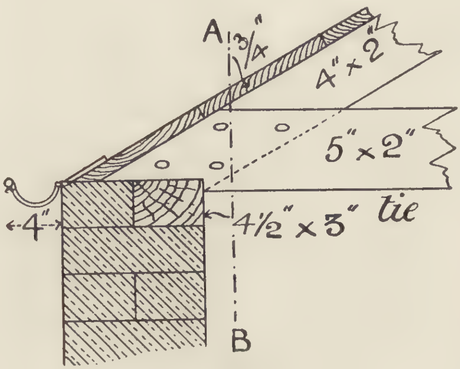


FIG. 171.

94. Collar roof.—This construction is inferior to that shown in fig. 170. The tie beam, instead of being placed so as to tie in the **feet** of the rafters, is situated as in fig. 172.

In this position, which should be about $\frac{1}{3}$ the distance from wall plate to ridge board up the rafter, it is known as a **collar.** The object of this method is to gain **head room.** The ceiling, if adopted, instead of being on a level with the top of the wall, is thus carried up into the roof.

It will be seen on referring to the figure that any deflection which may result from the rafters being subjected to a bending strain will take place below the collar, since the upper portions of the rafters are tied by it. Unless the walls are firm, they

will be forced outwards by the thrust resulting from the deflection. So long as the feet of the rafters remain immovable,

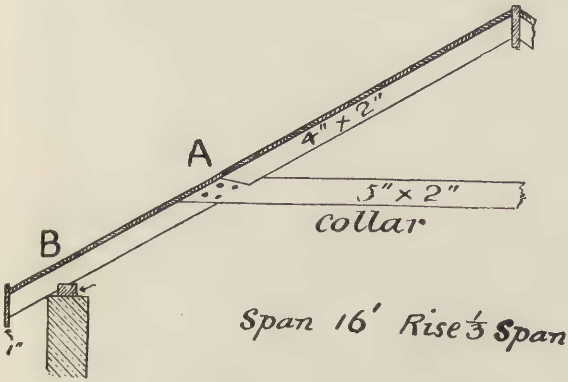


FIG. 172.

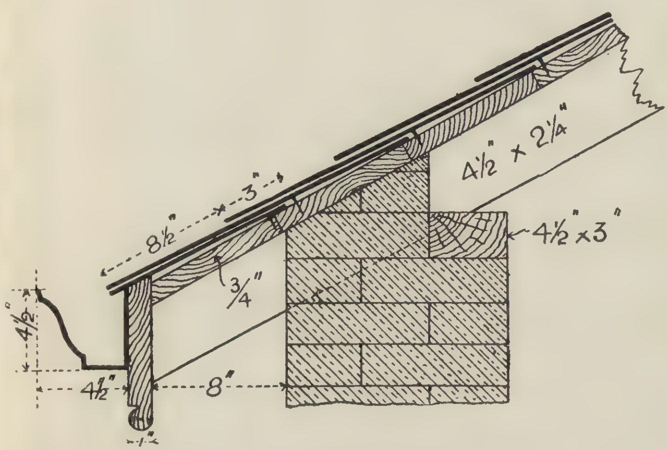


FIG. 173.

the collar acts as a **strut.** Under other circumstances, it serves the purpose of a **tie.**

Fig. 173 gives a modified detail of the rafter-foot B, fig. 172

This illustrates the method of forming an **eaves**. The rafters are carried beyond the wall-plate, so as to project beyond the walls, in this case 8 inches.

A **fascia board**, nailed to the ends of the rafters, gives a finished appearance to the work, and also carries the cast-iron **ogee gutter,** which is secured to it by screws.

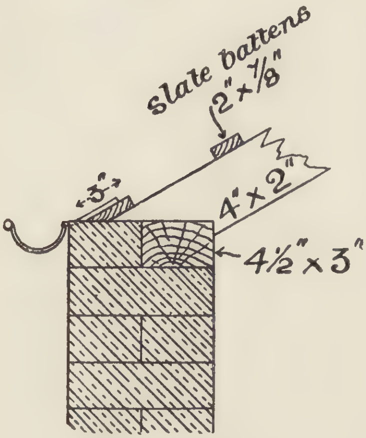


FIG. 174.

This fascia board is continued an inch or so above the roof boarding, thus serving the purpose of a tilting fillet (see Chapter VIII.)

It may here be remarked that a boarded roof, as shown in fig. 173, is much **cooler** in summer and **warmer** in winter than a battened roof (fig. 174). If **tiles** are used instead of **slates**, the same advantages accrue, only to a greater degree.

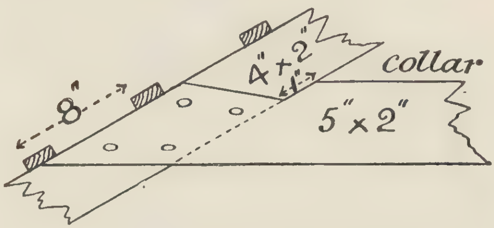


FIG. 175.

Fig. 174 shows another method of securing the rafters to the walls. The collar and rafter are joined as indicated in fig. 175. This has already been explained and illustrated in Chapter IV.

Collar roofs should not be used for spans exceeding 18 feet.

In addition to the collar, a beam or iron rod is sometimes added to tie in the feet of the rafters. When this is done the

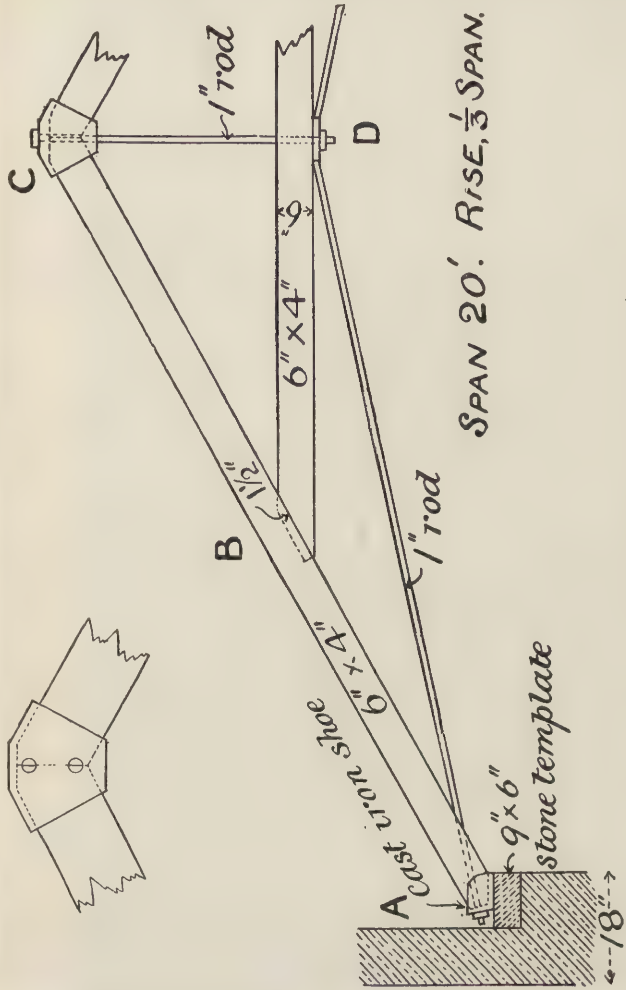


FIG. 176.

collar acts wholly as a strut. Both the collar and tie should in this case be supported by a bolt or wood strap hung from the

ridge. A roof of this kind may be used for spans up to 25 feet.

Fig. 176 is an example of a collar roof having an iron **tension rod** and **kingbolt**. The arrangement of the former is not so effective as it would be were it horizontal. The reason of its adoption is that more head room is secured. The collar in this instance is tenoned into the rafters, and straps are often used to strengthen the joints.

The foot of each rafter is received in a cast-iron shoe resting on a stone template, and secured to it by joggles. The tension rod passes obliquely through the foot of the rafter, and is furnished, at the back of the shoe, with a nut for tightening up.

The heads of the rafters pass into a cast-iron socket and butt one against the other. From this socket hangs the iron suspending rod, or kingbolt. This passes through the collar and tie rod, which is forged out at this point to admit it. A nut at its lower end allows of tightening up. By this means the roof may be rendered thoroughly stiff. In an iron and wood roof of this description the main point is to see that the wood fits perfectly in the sockets and shoes. Hence these are frequently **perforated**, in order that the joints may be inspected (see fig. 176).

95. King post roof.—For larger spans than those mentioned above, it is necessary that the roof should be supported by timber frames or **trusses** placed about 10 feet apart. When the space to be bridged over does not exceed 30 feet the form of truss of which a little more than one-half is shown in fig. 177 may be used. A roof of this description is termed a **king-post roof.**

The truss proper is composed of the following timbers: (1) **Tie-beam,** (2) **king post,** (3) **principal rafters,** (4) **struts.**

The other members which go to make up the complete roof are: (1) **Ridge board,** (2) **purlins,** (3) **pole plates,** (4) **wall plates,** or **templates,** (5) **common rafters,** (6) **gutter bearers,** (7) **roof boarding,** or **battens.**

These are all indicated in the diagrams. It will be well, however, to append definitions of the more important of them.

The **tie beam** is that member of the truss used to tie in the feet of the rafters.

The **king post** is a vertical piece inserted in order to

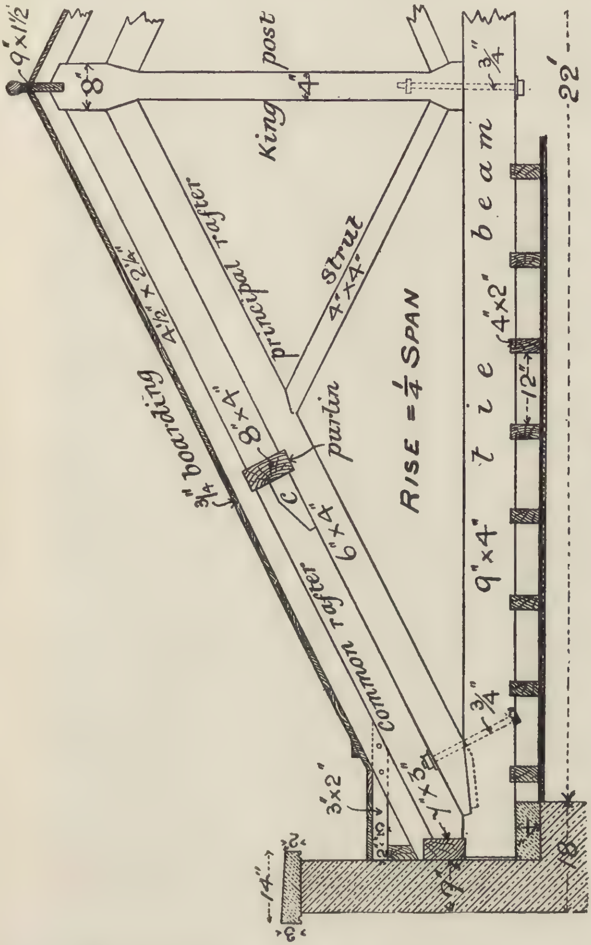


Fig. 177.

hang up the centre of the tie beam, and thus prevent it from sagging.

The **principal rafters** are inclined timbers framed at the lower end into the tie beam, and at the upper end into the head of the king post.

These carry the **purlins**, which in their turn support the common rafters. In some cases the common rafters are notched directly on to the principal rafters and run horizontally.

Struts are pieces framed at the lower end into the foot of the king post, and at the upper end into the principal rafters, in order to prevent the latter from sagging.

Purlins are timbers running horizontally across the **backs** of the principal rafters. The common rafters crossing these at right angles are thus supported at, or near, the middle of their length. The purlins are partly supported by wood blocks, or **cleats,** secured to the back of the principal rafters.

Ridge board, or ridge piece.—This is a board running the whole length of the roof, and supported in a groove, cut to receive it, in the head of the king post. The common rafters butt against the ridge board and are nailed to it.

Pole plates.—These are horizontal timbers (placed in different positions according to the form of the roof) to which the feet of the rafters are secured.

Wall plates and templates.—These have already been described. The term **wall plate** is generally given to any continuous piece of timber built into or carried on a wall, and used for distributing weight.

Templates are used for the same purpose. These are not continuous, but only of such length as is necessary to distribute the weight well over the brickwork. They may be stone or wood.

Common rafters are the direct supporters of the roof boarding. They usually run from ridge-piece to pole plate, being supported at one or two points by purlins. Sometimes, as already mentioned, they are placed horizontally on the principal rafters. This does not then necessitate the use of purlins.

Gutter bearers are pieces of wood used to carry the gutter boarding. They may be either framed into the pole plate, as in fig. 179, or simply nailed to the common rafters

(fig. 178). In each of these cases, one end of the bearer is supported on a **gutter plate.**

Roof boards, or battens.—These are nailed, generally at right angles, sometimes diagonally, to the common rafters, and carry the slates, etc., forming the roof covering.

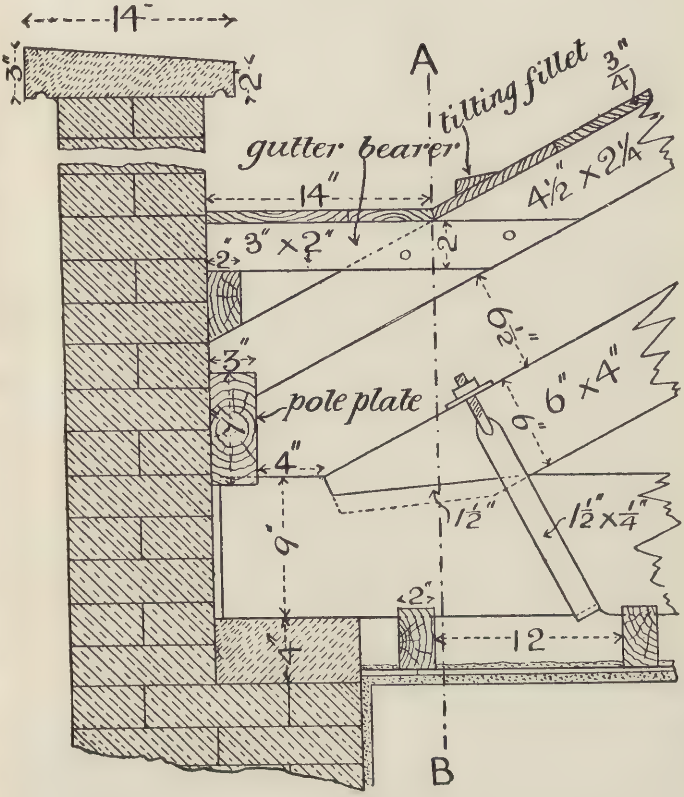


FIG. 178.

Having thus indicated briefly the position and purpose of the various parts of the roof shown in fig. 177, it remains to give a somewhat closer description of the various details illustrated.

Fig. 178 shows to a larger scale the joint of the principal rafter with the tie beam. The former is housed and tenoned into the latter, as described in Chapter IV. To assist the toe of the rafter in resisting the thrust, a wrought-iron strap has been added. By some, this strap would be placed nearer the toe than the heel of the rafter, as in fig. 185.

It is always advisable to bring this joint as nearly as possible over the wall plate, so that the weight of the roof may be more directly communicated through it to the brickwork. In this instance, the pole plate is notched on to the end of the tie beam. The end of the common rafter is birdsmouthed and nailed to the pole plate.

On the foot of the common rafter rests the gutter plate, which carries one end of the gutter bearer, the other end being nailed to the rafter. Frequently the end of the rafter is cut away, so that the gutter plate may rest on the pole plate. A tilting fillet of triangular section, for raising the lowest course of slates (see Chapter VIII.), is shown at the bottom of the slope.

In the example now before us the parapet wall is 18 inches above the highest point of the adjoining gutter.

One of the regulations of the Metropolitan Buildings Act requires that *if any gutter, any part of which is formed of combustible materials, adjoins an external wall, then such wall must be carried up so as to form a parapet one foot at least above the highest part of such gutter, and the thickness of the parapet so carried up must be at least eight and a half inches, reckoned from the underside of the gutter plate.*

With party walls this height must not be less than fifteen inches, measured at right angles to the slope of the roof.

In fig. 178 a lath and plaster ceiling is shown carried by joists notched on the under side of the tie beam.

Fig. 179 is a modification of the last. The arrangement of the pole plate is different, owing to the substitution of a cornice and blocking course for the brick parapet wall. It is fitted on the back of the principal rafter, which has to be cut, and consequently weakened, to receive it. One end of the gutter bearer is framed into it, the other being supported by a gutter plate, which rests on the stone cornice.

The purpose of the tilting fillet is illustrated here. An iron bolt is also shown at the foot of the principal rafter, in place of a wrought-iron strap.

Wood plates are very often used in place of stone templates for the tie beam to rest on. When this is the case, the beam should be secured to the plates by cogged joints (see Chapter IV.)

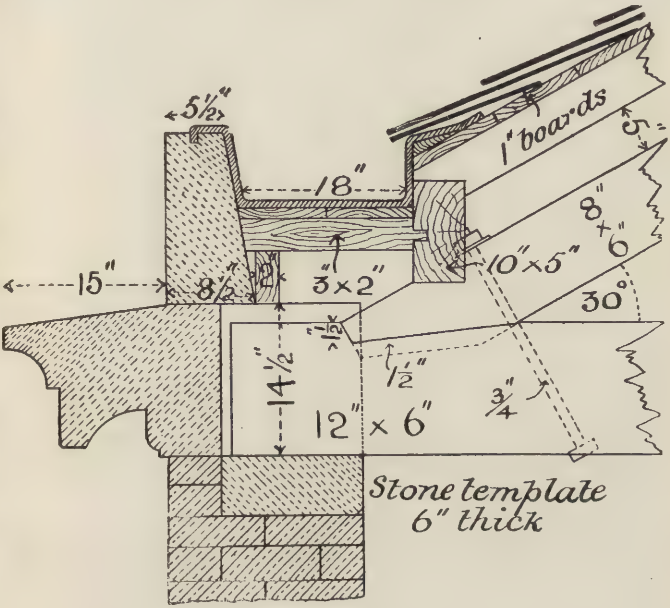


FIG. 179.

Fig. 180 is a detail showing the junction of a common rafter, a purlin, a principal rafter, and a strut. The usual plan is to notch and nail the purlin to the principal rafter. This has the advantage of keeping the trusses firmly apart. At the same time the rafter is not weakened by cutting away the material. In the case of the purlin this is not of such great importance.

Purlins are additionally supported by **cleats**. In fig. 177 the cleat is simply laid on the principal rafter and spiked to it, whereas in fig. 180 it is housed into the back of the rafter.

By this means the purlin is prevented from slipping down the roof.

A word or two with respect to the best position for the head of the strut. The object being to prevent the principal rafter from bending under the weight of the slates, etc., and this weight being transmitted through the purlin, it is evident that to prevent any **transverse** or **shearing** strain the point of support should be almost **directly under the purlin.** This is illustrated in fig. 180.

While advocating this arrangement, however, it must not be

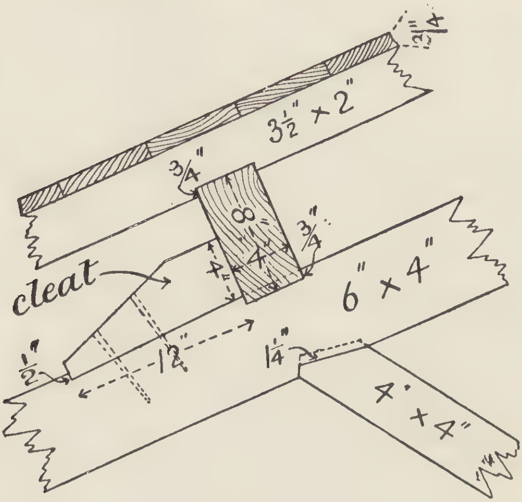


FIG. 180.

forgotten that, the more inclined a strut is from the perpendicular, the less effective does it become. Hence to avoid excessive inclination, the head of the strut is frequently kept higher up the rafter than the purlin, as shown in fig. 177.

Fig. 181 gives a detail at the head of the king post which is bevelled off so as to form a bearing for the ends of the common rafters. These may be checked out so as to fit the head (fig. 177), or simply laid on, as in the present instance. In either case they are bevelled to fit the ridge board, to which they

should be well nailed. The ridge piece is carried in a groove cut in the king post head.

The oblique joints between the king post and principal rafters were explained in the chapter on Wood Joints. Additional security is afforded in the present instance by a wrought-iron strap 2 inches wide and $\frac{1}{4}$ inch thick. When first put together the upper portions (*a*) of the oblique joints should be left a little open, or **slack**, as it is termed. On the roof settling, as it invariably does, these joints will close up. By this means the pres-

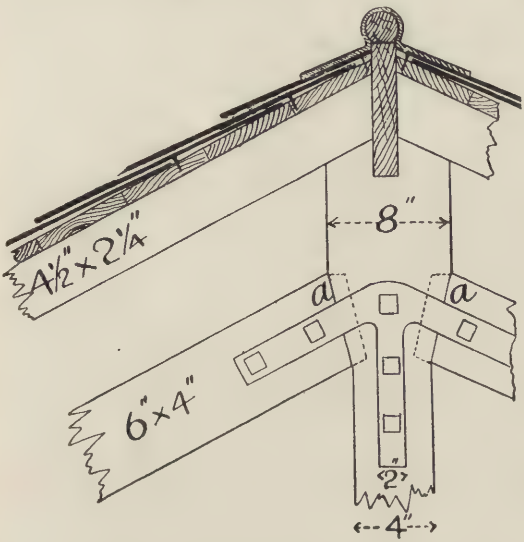


Fig. 181.

sure is equally distributed over the whole bearing surface instead of being confined to one portion, as would be the case if this allowance were not made.

It will be well for the student to consider for a moment the use of the king post, and the part it plays in maintaining equilibrium in the truss. On referring to fig. 177 it will be seen that as the ends of the principal rafters are securely fixed to the tie beam, and cannot possibly spread outwards, all weight brought to bear on them tends to bring the upper ends into

closer contact with the king post. This latter is, therefore, suspended between them. It **hangs** from the apex of the truss, and is not, as is frequently supposed, supported by the tie beam.

Fig. 182 illustrates the joints between the struts, king post, and tie beam. The oblique joints require no explanation.

The tie beam is **suspended** from the king post by means of a strap with gibs and cotters for tightening up. The section which is taken through the centre line of the king post, will explain the construction.

In fig. 177 a bolt passing up through the tie beam into the king post, where it is secured by a nut, is used for the same

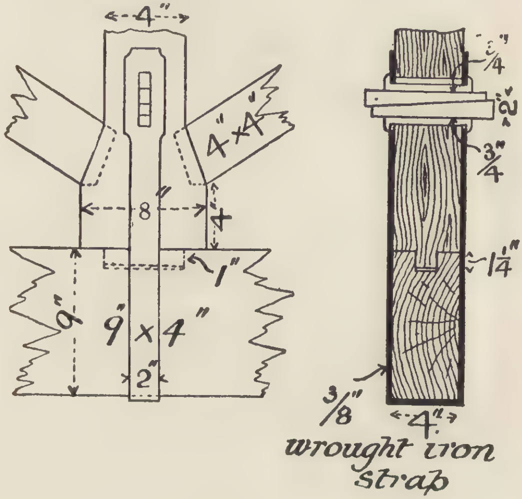


Fig. 182.

purpose, a broad washer being interposed between the bolt head and the wood. A stub tenon at the foot of the king post prevents lateral motion.

In constructing a roof truss of this kind the king post should be cut a trifle short. When the parts are put together, it will therefore be clear of the tie beam. After the slates have been laid, the roof is sure to settle on account of the increased weight. When this settlement has taken place, the tie beam may

be brought into close contact with the foot of the king post by either of the methods of tightening mentioned above.

It is usual, in this way, to give a slight camber to the tie beam, so as to counteract the effect of any sagging which may afterwards occur.

96. King bolt roof.—The truss used in forming a roof of this kind is a modification of the preceding. Instead of a wooden king post an **iron rod** or **bolt** is used.

In fig. 183 the principal rafters are shown secured at the head by a hollow cast-iron **socket** or **cap.** The rafters pass into the box and butt one against the other. The ridge board in this case is carried in a channel or groove cast in the head itself. The king bolt passes through the socket and is secured by a nut below the tie beam. An iron plate which clips the sides of the tie beam is interposed between the nut and woodwork. One method of forming an abutment for the lower ends of the struts is shown. They are kept apart by means of a **straining piece** spiked to the tie beam. Another way would be to form a joint similar to that shown in fig. 156.

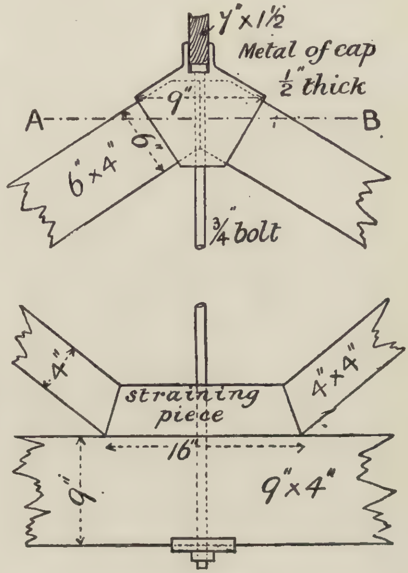


FIG 183.

97. Trussed rafters.—Instead of using framework of the form previously described for carrying a roof, the system of supporting it on trussed rafters is very commonly adopted.

Fig. 184 illustrates rather more than one-half a truss of

this description, designed for a large greenhouse. The foot of each rafter is secured in a cast-iron shoe resting on a

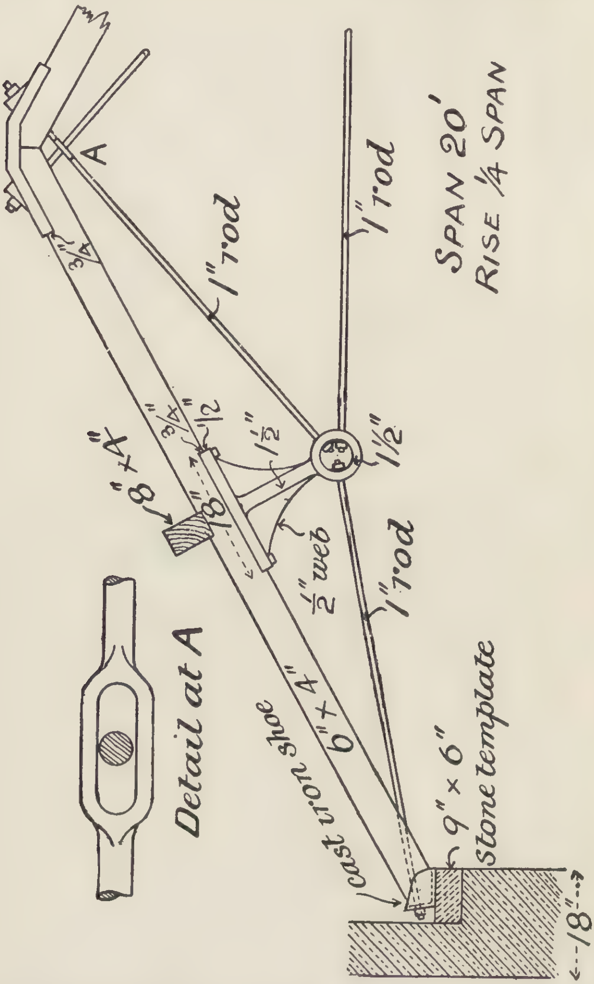


Fig. 184.

stone template and secured to it by joggles. The rafters butt one against the other at the apex. At the centre of each rafter,

and on the underside, is secured a **cast-iron strut** furnished with a hollow circular head of 6 inches internal diameter, to receive the nuts at the ends of the **tension rods.** One of these rods passes from the box to the foot of the rafter and is secured at the back of the cast-iron shoe by means of a nut. The other runs to the apex and is fastened in a similar manner. It will be noticed that two **facings,** as they are termed, are cast on the iron cover plate at the head of the rafters. These afford a bearing for the nuts, at right angles to the direction of the tension rods.

Where the tension rods cross (A, fig. 184), it is necessary to form a slot in one of them, as shown in the detail. This allows the other rod to pass through. In forging it out, care must be taken that the cross-sectional area is not reduced so as to leave it weaker than the other portion of the rod.

A horizontal tie rod secured between the heads of the struts prevents the rafters from spreading outwards.

98. Queen post roof.—Although the consideration of queen post roof construction does not fall within the limits of the elementary course, it has been deemed advisable to touch lightly on it, so that the student may compare it with the forms previously described and illustrated. Fig. 185 gives a general idea of the disposition of the various members.

The example given is designed for a span of 45 feet. Beyond this it becomes necessary to slightly modify the construction, as shown by the dotted lines, the upper triangular portion above the straining beam being in fact converted into a **king post truss.** Instead of a central (king) post there are two queen posts, usually placed so as to divide the tie beam into three equal parts. These are kept apart at the upper ends by means of a **straining beam,** while below, a **straining sill** spiked to the upper side of the tie beam is employed for a like purpose. The remaining timbers are known by the same names, and are put together in the same way, as the members of a king post roof. Two details are given in order to render the construction more intelligible.

Fig. 186 shows the **queen post head.** Into it the principal rafter and straining beam are tenoned, the latter being housed

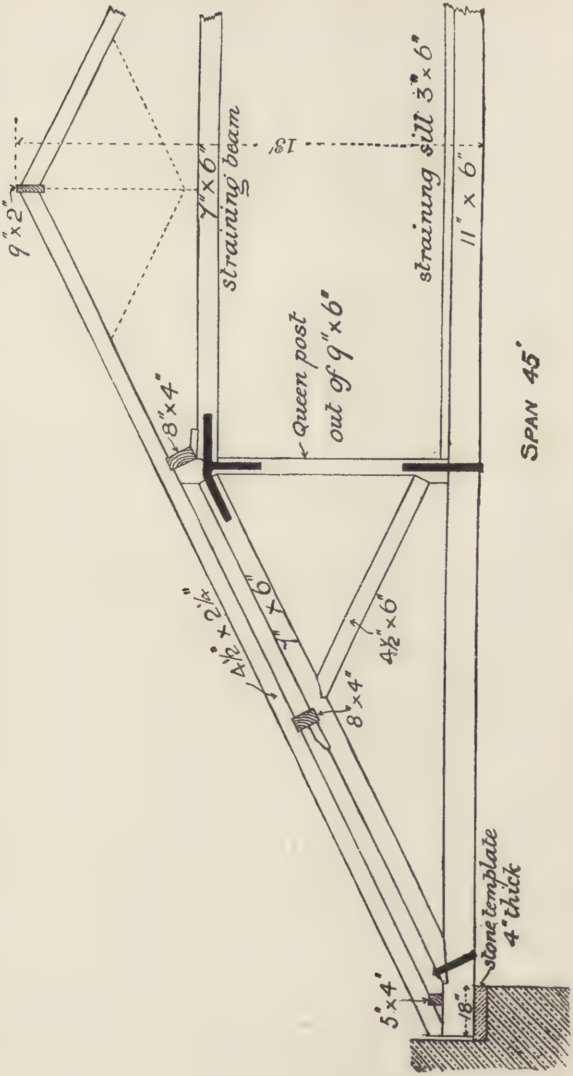

9"×2"
13'
7"×6"
straining beam
straining sill 3"×6"
11"×6"
Queen post
out of 9"×6"
SPAN 45'
8"×4"
4½"×2½"
7"×6"
4½"×6"
8"×4"
5"×4'
18"
stone template
4" thick

FIG. 185

for the purpose of additional support. The head is cut back at right angles to the slope of the roof, and a **cleat** is nailed

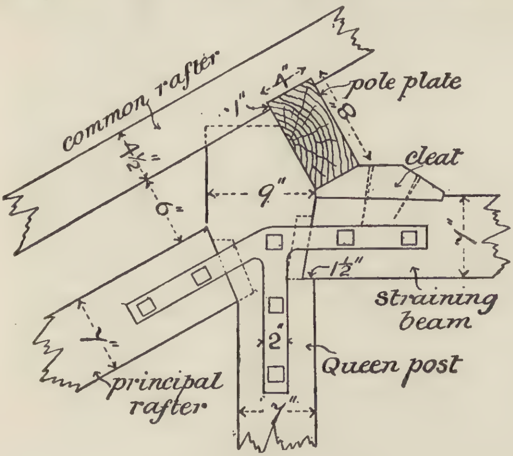


FIG. 186.

on the top of the straining beam. In the angle thus formed between the cleat and head of the queen the purlin is secured.

Sometimes the queen post head is left square and the common rafter notched out to fit on the angle, as shown by the dotted lines. The several members are united by a wrought-iron strap 2 inches wide and $\frac{1}{4}$ inch thick.

A detail of the joints at the foot of the queen post is shown in fig. 187. Structurally these resemble the joints shown in fig. 182. The straining sill is nailed to the tie beam, and simply butts against the foot of the queen post. It thus prevents the latter from being displaced by the thrust of the strut.

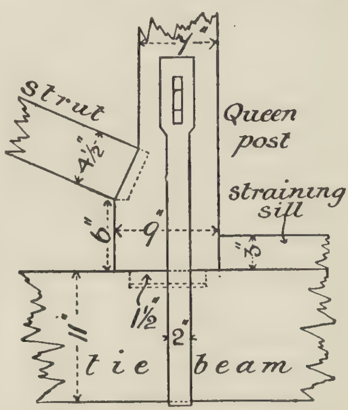


FIG. 187.

Exercises on Chapter VII.

Note.—In several of the examples in this chapter slates and leadwork have been shown in position. This has been done to illustrate the chapters on Plumbing and Slating.

The student is therefore advised to read Chapters VIII. and IX. before attempting to include these details in his drawings.

1. Draw fig. 166 to a scale of $\frac{1}{16}$. Add a plan, the roof boarding being removed. Principals 10 feet apart, common rafters 12 inches in the clear. Only the lower six rafters need be shown.

2. Draw to a scale of $\frac{1}{6}$ the details shown in figs. 167, 168, and 169.

3. Draw complete to a scale of $\frac{1}{12}$ the couple roof shown in fig. 170, slate battens $2'' \times \frac{7}{8}''$, and $8''$ apart from centre to centre.

4. Draw the detail given in fig. 171 to a scale of $\frac{1}{4}$, and show a section on A B.

5. Draw to a scale of $\frac{1}{12}$ the collar roof, fig. 172. Show the collar suspended from the ridge piece by a $\frac{3}{4}''$ iron bolt, the former to be $7'' \times 1\frac{1}{2}''$; the rafters to project $8''$ beyond the wall.

6. Draw figs. 173, 174, and 175 to a scale $\frac{1}{6}$, adding in the first two cases a side elevation of the roof, slates to be omitted.

7. Fig. 176 gives a part elevation of a collar roof with tie rod and king bolt. Draw to a scale of $\frac{1}{12}$. Sketch freehand details of the joints at A B, C, and D.

8. Draw to a scale of $\frac{1}{12}$ the half elevation of a king post roof shown in fig. 177.

9. Fig. 178 is a detail at the foot of the principal rafter in the preceding figure. Draw to a scale of $\frac{1}{4}$; show also a vertical section in A B.

10. Draw fig. 179 to a scale of $\frac{1}{6}$. Add a plan, the slates and leadwork being omitted.

11. Detail at the head of the strut in a king post roof, fig. 180. Draw to a scale of $\frac{1}{4}$. Show a plan with the slate boarding removed.

12. Draw fig. 181 to a scale of $\frac{1}{4}$. Give also a horizontal section through the oblique joints at the king post head.

13. Draw the views given in fig. 182 to a scale $\frac{1}{4}$ full size.

14. Details of a king bolt roof truss, fig. 183. Draw to a scale of $\frac{1}{4}$, and add a section on A B.

15. Draw to a scale of $\frac{1}{12}$ the roof truss given in fig. 184. Sketch freehand, about $\frac{1}{4}$ full size, details showing the ends of the tension rods and the method of securing them. Give also a cross section of the cast-iron strut.

16. Diagram of a queen post roof, fig 185. Draw to a scale of $\frac{1}{2}''$ to a foot.

17. Detail at the head of a queen post, fig. 186. Draw to a scale $\frac{1}{4}$ full size, showing the head cut square and the rafter birdsmouthed to fit it.

18. Draw the joint at the foot of the queen post, fig. 187, to a scale of $\frac{1}{4}$. Add a vertical cross section through the middle of the strap, the latter to be $\frac{3}{8}''$ thick.

19. Joint between the foot of a principal rafter and the tie beam of a wooden roof truss, showing the end of the tie beam resting on a brick wall, fig. 188 (*a*). Draw to a scale of 2″ to a foot, making any alterations you consider necessary and adding a heel strap 2″ wide.

20. Elevation of the junction between the foot of a king post and a tie beam, fig. 188 (*b*). Give a cross section on A B to a scale of $1\frac{1}{2}''$ to a foot, showing all the details connected with the stirrup iron.

21. Elevation of the foot of the principal rafter, and of the end of the

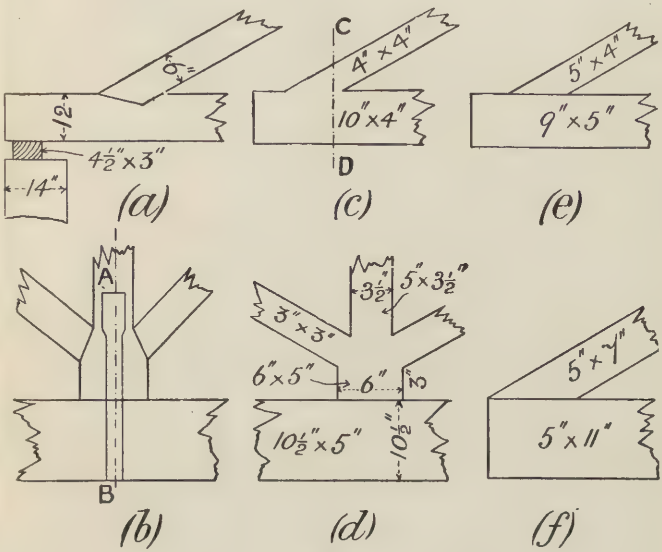


Fig. 188.

tie beam of a small king post truss, fig. 188 (*c*). Draw to a scale of 1″ to a foot; show how the joint is cut and give a section on C D.

22. Elevation of the foot of a king post with struts and tie beam, fig. 188 (*d*). Draw to a scale of 1″ to a foot and show the joints. The parts of the joints hidden are to be indicated by dotted lines.

23. Give a side view and front elevation on a scale of 1″ to a foot of a stirrup with gib and cotter for the joint in the last question, the iron of the stirrup to be $1\frac{1}{2}'' \times \frac{3}{8}''$.

24. Elevation of the end of a roof truss, fig. 188 (*e*). Draw to a scale

of 1″ to a foot, showing how you would form the joint, using a wrought-iron bolt to secure it.

25. Elevation of the foot of a principal in a wooden roof truss, fig. 188 (*f*). Draw to a scale of $\frac{3}{4}$ of an inch to a foot, showing the details of the joint with a $\frac{3}{4}$″ bolt to secure the same. Write its name on each member.

26. Elevation of the head of a roof truss incorrectly drawn, fig. 189 (*a*). Draw correctly to a scale of 2″ to a foot, showing the details of the joint at A, and writing against *b*, *c*, *d* their names. No iron work is required.

27. A line diagram of a wooden roof truss, showing the scantlings of the various timbers, fig. 189 (*b*). Draw to a scale of $\frac{1}{60}$, giving the name of the truss and of each member of it.

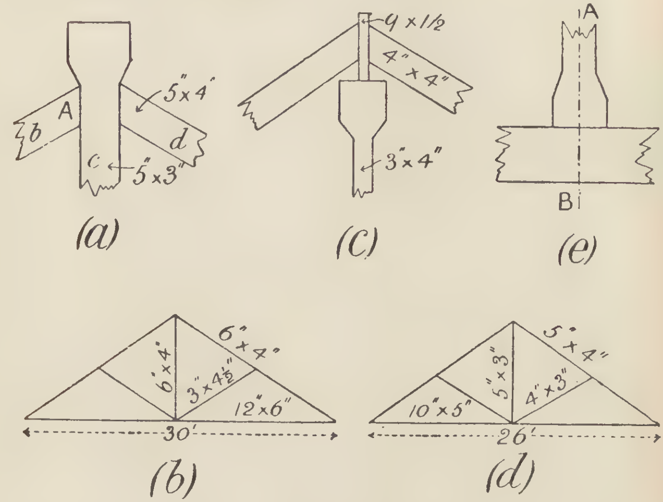


Fig. 189.

28. Joint at the head of a small wooden truss, fig. 189 (*c*). Draw to a scale of $\frac{1}{6}$, making any corrections you may consider necessary. Write its name against the truss and against each of the members shown.

29. A skeleton diagram of a wooden roof truss, fig. 189 (*d*). Draw the truss to a scale of $\frac{1}{60}$ and give the names of its different members.

30. Elevation of the foot of a king post at the centre of a tie beam, fig. 189 (*e*). Give a section through A B to a scale of $\frac{1}{12}$, showing all the details of a stirrup iron with gibs and cotters.

31. Put together and draw in sectional elevation (scale $\frac{1}{2}$″ to 1′) the following timbers for a collar-beam roof, 14′ span from centre to centre of wall plates, rise $\frac{1}{4}$ the span, the collar to be half-way up the rafter and to be

suspended in the centre from the ridge by a light iron rod ; the eaves to project 10″ beyond the walls, which are to be 1 brick thick and of which the four upper courses, with the joints of the brickwork, are to be shown ; wall plates $4\frac{1}{2}'' \times 3''$ resting on centre of walls, rafters $3'' \times 2\frac{1}{4}''$, ridgeboard $7'' \times 1\frac{1}{2}''$, collar $4\frac{1}{2}'' \times 2'$, slate battens $3'' \times 1''$ arranged for countess slates $20'' \times 10''$ with 3″ lap, bevelled batten 3″ wide as tilting fillet.

32. Give an elevation to a scale of 1″ to 2′ of a little more than half a king post roof truss resting on 14″ brick walls, 20 feet apart, taking the following scantlings : Wall plates $4\frac{1}{2}'' \times 3''$, tie beam $9'' \times 3''$, principals $6'' \times 3''$, struts $3'' \times 3''$, king post $4'' \times 3''$, heel straps and stirrup iron 2″ wide.

33. Draw skeleton diagrams showing the difference between a king post and queen post roof truss, writing the names against the different members.

34. Draw to scale of $\frac{1}{36}$ a wooden truss for a 33′ span, taking the following details : Principals $5'' \times 4\frac{1}{2}''$, tie beam $8'' \times 4\frac{1}{2}''$, struts $4'' \times 2\frac{1}{2}''$, straining beam $7'' \times 4\frac{1}{2}''$, queen bolts of 1″ round iron.

35. Draw to a scale of 1″ to 3′ a cross section through a couple roof resting on 9″ brick walls 12′ apart. Rafters and wall plates to be $4'' \times 2''$, ridge board $7'' \times 1\frac{1}{2}''$. Only the four top courses of the walls to be shown, with the eaves projecting 9″.

36. Draw to scale of an inch to 6′ a single line diagram showing the form of a king post roof truss for a 30′ span, the rise being $\frac{1}{4}$ the span. Write their names on the different members and draw $\frac{1}{6}$ full size an elevation of the joint at the top of the truss, the members consisting of a cast-iron head, $5'' \times 5''$ timbers, and an iron rod $1\frac{1}{4}''$ diameter.

37. Show by single line diagrams a collar beam roof and a king post roof truss, marking the names on the different parts.

38. Draw to a scale of an inch to 5′, from the following details, an elevation of a roof truss for a 25′ span. Tie beam $4'' \times 10''$, principals $5'' \times 4''$, struts $4'' \times 2''$, king rod $\frac{3}{4}''$ round iron.

39. Draw to a scale of an inch to 8′ single line diagrams showing—a king post truss for a span of 25′, rise to be $\frac{1}{4}$ span ; a queen post truss for a 40′ span, rise to be $\frac{1}{3}$ span.

40. Give a sectional elevation to a scale of 4′ to an inch of a wooden king post roof truss resting on 14″ brick walls, 20′ span, using the following scantlings : Tie beam $10'' \times 4''$, principals $5'' \times 4''$, king post $4'' \times 3''$, struts $3'' \times 2''$, purlins $8'' \times 4''$, pole plate $6'' \times 4''$, wall plates $3'' \times 4\frac{1}{2}''$, ridge piece $8'' \times 1\frac{1}{2}''$, common rafters $3'' \times 2''$.

41. Give to a scale of 3′ to an inch an elevation of a collar beam roof truss for a 12′ span. Show $4\frac{1}{2}'' \times 3''$ wall plates resting on 14″ brick walls, rafters $5'' \times 3''$, collar $4'' \times 2''$ half-way up, ridge piece $9'' \times 1\frac{1}{2}''$.

CHAPTER VIII.

SLATING.

Note.—The thickness of the slates and lead shown in the drawings has been exaggerated in order to render the diagrams more intelligible.

99. **General remarks.**—Among the various materials used as roof coverings are the following :—**Slates, tiles, boarding, sheet zinc, sheet lead, corrugated iron, sheet iron, sheet copper**, and **asphalted felt.**

The student is required, for the elementary course in building construction, to render himself familiar with only the first of these.

Slates may be used on roofs of almost any pitch. Practically, however, it is found that when the slope is below 26 degrees, or thereabouts, it is difficult to keep the slate covering weatherproof. If the roof is steep, the slates must be **smaller** and **lighter** than those used for flatter slopes. It will be easily understood that the wind has more chance of lifting and displacing slates when the pitch is low. Hence this is avoided by increasing their weight. The following sizes of slates are in common use :—

Name of Slate	Size in Inches
Singles or smalls	12×8
Doubles	13×6
Ladies (small)	14×12
Ladies (large)	16×8
Countesses	20×10
Duchesses	24×12

There are two methods of nailing slates—viz. (1) near the head, (2) near the centre. The respective advantages of these systems will be described presently.

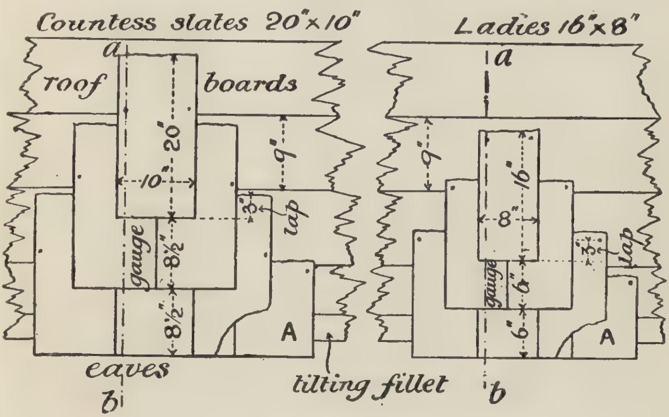
When slate boarding is used, it is often covered with asphalted felt before the slates are laid. This material keeps the roof

timbers dry when leakage occurs through defects in the slating. It is, besides, an excellent non-conductor of heat.

For the sake of appearance and soundness, the slates to be used for a roof should be sorted into three divisions according to their thickness, which varies. The thickest must be laid at the bottom of the roof slope, and the thinnest at the top near the ridge.

The following terms are applied to the different parts of a slate:—

(1) Bed . . .	the under surface.
(2) Back. . .	the upper surface.
(3) Tail . . .	the lower edge.
(4) Head . .	the upper edge.
(5) Margin . .	the portion of each slate exposed to view on the outside of the roof.



FIGS. 190 and 191.

Slates may be secured to **roof boarding** or **battens**. In every case **two** nails should be used to fasten each slate. These are preferably of **copper,** and about 1½ inch long. **Zinc** and **iron** are sometimes used ; when of the latter material. the nails should be well **galvanized** or dipped in **boiled oil** to prevent corrosion.

100. Lap.—This term is applied, in the case of slates

nailed at the head, to the distance which the **tail of one course of slates** overlaps the **nail holes of the course next but one below** it.

Thus in fig. 191, which illustrates the arrangement of slates 16 inches long and 8 inches broad (**ladies**), the lap is given at 3 inches.

In fig. 190 the slates (**countesses**) are large, being 20 inches long and 10 inches wide. These are preferably nailed near the centre. When this is the case, the lap is taken as the distance between the **tail of one course** and the **head of the course next but one below** it: this is clearly indicated in the figure.

101. Gauge is the technical term given to the width of the **margin.** It may be defined in the case of slates nailed near the head as **half the difference between the lap and the distance between the nail holes and the tail of the course.**

The nail holes may be reckoned as being one inch from the head of the slate.

Example.—Fig. 190. Find the gauge with slates $16'' \times 8''$ nailed at the head, the lap being $3''$.

$$\frac{15'' - 3''}{2} = 6''. \quad \text{Gauge} = 6''.$$

With slates nailed near the centre the gauge is equal to **half the difference between the whole length of the slate and the lap.**

Example.—Fig. 190. Find the gauge with slates $20'' \times 10''$ nailed near the centre, the lap being $3''$.

$$\frac{20'' - 3''}{2} = 8\tfrac{1}{2}''. \quad \text{Gauge} = 8\tfrac{1}{2}''.$$

The nail holes in this case are at a distance from the tail equal to **the gauge + the lap + one inch.**

102. Dressing the slates.—After being sorted, as previously described, the slates are dressed to one size, cut square on three edges out of four (the head being left rough), and the nail holes made. These holes are punched through from that side of the slate which is to lie **undermost**. The edge of the hole on that side of the slate at which the punch comes through

is splintered, and is thus **countersunk,** as it were, to receive the head of the nail.

103. Laying the slates.—It will be seen from the illustrations that the joint between any two slates comes on the **centre line** of the slate below. On looking at a well-slated roof it will be noticed that the tails of the slates run in horizontal lines, and the joints between the slates in lines perpendicular to the ridge.

It need hardly be remarked that all roofing slates should be carefully cut and squared so as to lie as close together as possible.

The student will find examples of slating (in section) in figs. 167, 169, 173, 179, 181, 197, and 199. In these figures thick lines represent the slates.

With respect to the method of nailing near the head, it may be said in its favour that **each nail hole** is covered by **two slates.** This is an advantage, since if by any chance one slate is broken, the nail is still covered by the other. On the other hand, slates secured in this way are not so capable of resisting the tearing-up effect of wind, owing to the longer leverage offered.

This is not so marked in the case of small slates, to which head nailing should therefore be confined.

When slating laths are used, the first one at the eaves should be about one inch thicker than the others (fig. 170), so that the lowest course of slates may be tilted up. This is necessary in order that the second course may lie closely on the first. No open space should be left for the wind to enter. If close boarding is used, a triangular **tilting fillet** is nailed along the eaves for the same purpose, fig. 178.

When, as in fig. 173, a **fascia board** is used, it may be continued an inch or so above the roof boarding and utilised for the same purpose.

On referring to figs. 190 and 191 it will be noticed that the slates at the eaves are laid double. The lowermost slates are from nail hole to tail equal in length to **one half that of the whole slate.**

This forms what is known as the **eaves** or **doubling**

course. The highest course next to the ridge piece is also a double one, fig. 181, the length of the slates in the **ridge course** being the same as at the eaves.

Where the slope of the roof is intersected, or met, by a chimney, wall, dormer window, skylight, etc., the slates should be raised a little by a tilting fillet along the edge of the inclined gutter. This is illustrated in fig. 207. The same remark applies to the slating in V-gutters and valleys, figs. 204 and 205.

104. Slate and tile ridges.—Sections of slate ridging are shown at (*a*) and (*b*), fig. 192. In the first of these the **roll** and one **wing** are in the same piece.

At (*b*) the roll is quite separate from the wings. The latter are put together and secured by **copper screws.** The ridge roll is then cemented on, as shown.

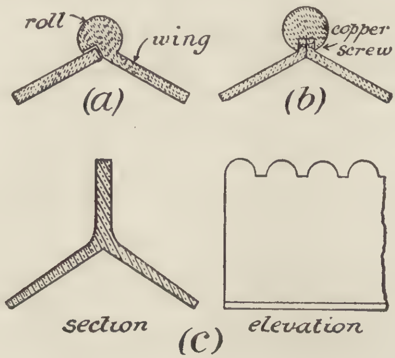


Fig. 192.

At (*c*) is shown a form of tile ridging in common use.

When slates are laid on battens they are sometimes pointed on the inside with **coarse stuff**—i.e. lime and hair mortar. In some parts this is known as **torching.** Occasionally the whole underside of the slates is **rendered** with the same material.

Several methods have been introduced of covering roofs with very large slates laid from rafter to rafter, thus dispensing with slate boarding and battens. As a rule, however, these are neither economical nor satisfactory, and consequently are seldom used.

CHAPTER IX.

PLUMBING.

105. General remarks.—In forming **gutters, flashings, lead flats, ridge coverings**, etc., the following points should be noted. All sheet lead must be laid with a **slope** or **fall**, in order to let the water drain off. This fall should not be less than $\frac{1}{4}$ inch for every foot of length.

When sheets of lead have to be joined, they should not be rigidly fixed by soldering one to the other. The sun shining on the lead causes it to **expand**, while cold causes **contraction**. Allowance must, therefore, be made for this, and the lead secured in such a manner that a little play is allowed. This prevents the sheets from buckling.

For the same reason it is much better to cover a surface with several small sheets than to use a single large one. In practice it is usual to employ **quarter sheets**—i.e. pieces 10 feet long and 3 feet wide or thereabouts—for ordinary purposes.

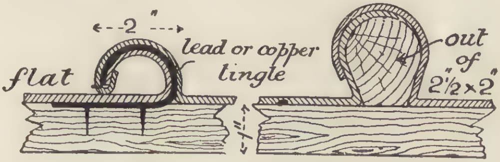
106. Joints for sheet lead.—**Rolls.**—These are used for joining sheets of lead on flats. In forming the joint a wooden roll (fig. 194) is first nailed or screwed to the boarding. This roll is preferably of the shape shown in the figure. One of the sheets of lead is first dressed well into the angle and just beyond the crown of the roll. The second sheet is then treated in the same way, and brought over to within a short distance of the horizontal sheet on the other side. Some plumbers hold that the outer sheet of lead should be taken quite over the roll and dressed down an inch and a half or so on the flat beyond. This, however, should be avoided.

One object of the introduction of rolls is to allow for the due **expansion** and **contraction** of the lead, caused by changes of temperature. By carrying the lead too far over the roll it is unnecessarily confined.

Again, any water which may be lying on the flat will be sucked up into the joint by **capillary attraction** and find its way into the woodwork. This will also take place with the

construction recommended, if any rain happens to be blown up to the edge of the outer sheet. The lap must, therefore, be on **the side least exposed to the wind and rain.**

The hollow roll illustrated in fig. 193 does not require a wooden core. In forming this, the edges of the sheets are turned up against one another, the upstand in one sheet being about $3\frac{1}{2}$ inches and in the other an inch less. The higher edge is then dressed closely over the other, strips of lead known as **tingles** or **clips** being inserted between the sheets at intervals of 2 feet or thereabouts along the roll. These tingles are about 3 inches broad. The lower ends are nailed to the boards, as shown in the figure, being let into them the thickness of the lead.



FIGS. 193 and 194.

At the edge of a flat it is necessary to turn the lead over in the form of a **roll** or **nosing**. Two methods of doing this are illustrated in fig. 195. In the first case a strip of lead is shown covering the upper course of slates and turned up against the flat. A wooden roll is nailed along the upper edge, and over this is dressed the lead sheet of the flat.

In the same figure is shown a **flat nosing**. This is formed, with the exception of the tingle, in the same way as the lead roll in fig. 193, being afterwards dressed close to the woodwork. Sometimes, however, it is left semicircular.

With regard to the use of the hollow rolls and nosings, there is this to be said in its favour. The lead is left quite free to expand or contract. At the same time, where there is traffic, hollow rolls are more easily damaged.

107. Seams.—Instead of rolls the plumber frequently joins his lead sheets by means of seams. To do this the edges of the sheets are bent up at right angles, one standing up beyond the other. After turning one over the other they are

both dressed down as close as possible to the flat. The flat nosing given in fig. 195 may be termed a **seam.**

108. Lap joint.—This is made by simply lapping one sheet over the other for a distance usually of 6 inches.

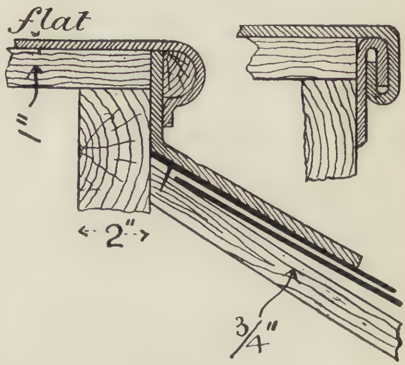


FIG. 195.

109. Ridges.—In fig. 192 are shown examples of slate and tile ridging. These are in great use at the present time. Lead was at one time almost exclusively used for this purpose, but has been largely superseded by the materials mentioned above. Zinc is also employed for the same purpose, while cast-iron ridging can now be obtained to suit all pitches. The latter material, however, becomes eventually the most expensive on account of the frequent painting it requires.

Fig. 196 shows the ridge board carried 3 inches above the roof **boarding**. Over this is dressed sheet lead, which should come down over the slates at least 6 inches, forming **wings,** which must be dressed close to the roof. Lead-headed nails are frequently driven through the ridge covering into the ridge board, in order to prevent the former being stripped off by the wind.

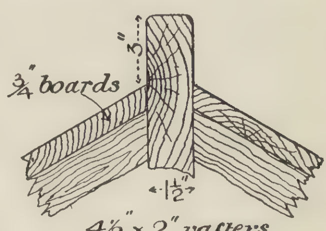


FIG. 196.

This is the simplest method of finishing the ridge. The sheets of lead used should not exceed 7 feet in length, the overlap being 6 inches.

In order to preserve a perfectly straight line along the top of the roof, the ridge board or roll, presently to be described,

should be checked out at the part where the sheets overlap. Into this space the lower sheet is carefully dressed. The upper length may then be carried over in a continuous straight line.

In fig. 197 the ridge is surmounted by a roll, and over this the lead is laid. In some cases the roll is flat on the underside and nailed to the ridge piece itself.

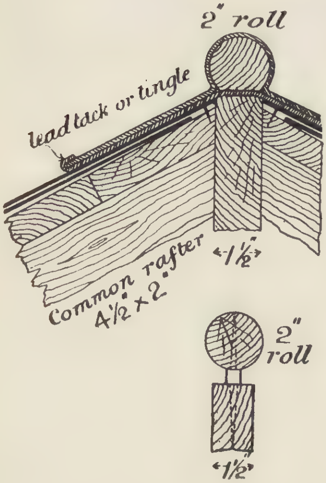


Fig. 197.

In others, it is carried on shouldered iron spikes driven first into the ridge. The roll has then to be bored through in places, so as to fit on these spikes, which are then riveted over at the top. In either case the lead is dressed over the roll and well into the angles. By this means the sheets are made to clip the roll, and nails are not required to keep them in position.

There is a tendency, however, for the wind to get in underneath the wings and strip them from the slates. A method of preventing this is given in fig. 197. Strips of lead known as **tacks** or **tingles** are laid over the ridge at intervals along its length. The roll is then nailed down, or secured by spikes driven into the ridge to support it. After the lead ridge covering is dressed over the roll, the ends of the tingles are bent over so as to clip the edge of the wings and prevent them from lifting.

Hips are covered with lead in the same way as ridges.

109 A. Flashings.—In fig. 195 a strip of sheet lead is used to cover the joint between the roof slope and flat, so as to prevent any wet finding its way into the woodwork. Pieces of sheet lead used for this purpose are termed **flashings**.

Examples will be found in the following figures, 169, 179, 199, 200, 206, 207.

In fig. 169 the flashing is continued up the wall for about 6 inches and then into a **raglet** formed by raking out the mortar from the brickwork joints. **Lead wedges** or wrought-iron **holdfasts** are then driven in between the lead and the brickwork to secure it. The joint is afterwards **pointed with cement** to keep the water from following the lead into the wall.

In fig. 179 the lead of the gutter itself is turned up against the blocking course and secured in a raglet cut along the top. It will be noticed in this figure that the sheet of lead is very wide. Its expansion and contraction are therefore considerable. To confine the edge of the lead in a raglet is consequently not advisable. A much better plan would be to turn up the gutter lead against the blocking course within an inch or two of its upper edge. A sheet of lead termed an **apron** may then be secured at one edge in the raglet, and dressed over so as to hang freely some three or four inches below the edge of the upstanding sheet. This leaves the latter free to expand and contract under changes of temperature.

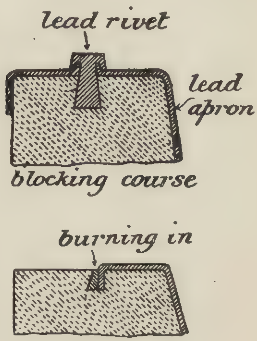


FIG. 198.

The lead sheet may be secured in the raglet by running in **cement**. Another method, known as **burning in**, is given in fig. 198. The raglet is first undercut. After the edge of the lead sheet has been turned down into it, molten lead is poured in. When cold it is well **caulked** so as to completely fill the raglet. Sometimes the apron is continued over the top of the blocking course and turned down about one inch on the other side (fig. 198). Before this is done, holes about $1\frac{1}{2}$ inch deep and 3 feet apart are cut in the top edge of the blocking course. These should be dovetail in section. Small holes, which are afterwards opened out, are made in the apron directly over those in the stonework. The apron is then put on and molten lead is poured into the holes, so as to fill them up and stand above the apron, forming **buttons** or **rivets** to secure it to the blocking course. When cold, a few

taps with the hammer will cause them to fit tightly in the holes. Several examples of lead aprons are given in this chapter.

110. Raking flashings.—Where a chimney, or wall, intersects the slope of a roof, it is necessary to protect the joint by means of a lead **flashing**. This, necessarily following the pitch of the roof, is called a **raking flashing**. The lead is dressed down on the slates for a width of 7 or 8 inches and turned up against the wall 6 inches, the upper edge being secured in a raglet cut in the brickwork or masonry parallel to the slope.

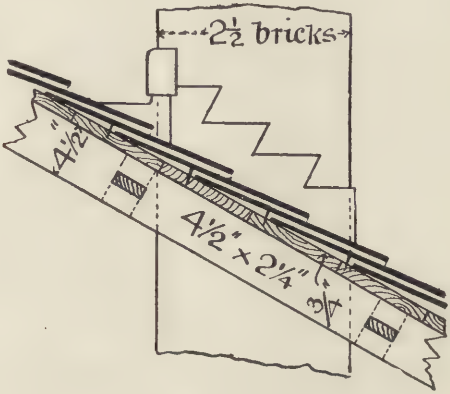


FIG. 199.

As mentioned in Chapter VIII., the slates are tilted up at the side nearest the wall or chimney so as to throw the water away from the joint.

Instead of securing the upstanding lead in the raglet, an apron may be used in the same way as previously described.

The great disadvantage of using raking flashings is, that the raglet has to be specially cut in the brickwork. To avoid this the lead may be cut into steps, as in fig. 199. The horizontal portions only of these are turned into the raglets, which in this case are formed by raking out the joints in the brickwork.

When cutting the steps in the lead care should be taken that they do not come within 2 inches at least of the part which is to lie on the slates. The defect of this method is, that the

water sometimes finds its way into the brickwork at the lower angles of the steps. To avoid this, the lead should be picked up slightly at those points, so that the bricklayer, when pointing, can squeeze in a little cement to keep out the weather.

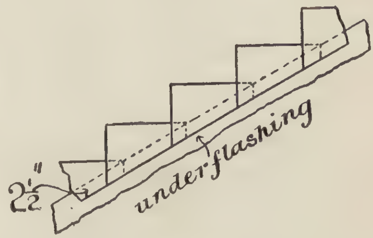


FIG. 200.

Another method of forming the flashing is shown in fig. 200. In this case the under flashing is about 9 inches broad. Of this one-half is dressed down on the slates, the remainder being turned up against the wall. The apron is hung in pieces, one to each step, so as to overlap each other and the upstanding lead about 2 inches. The horizontal joints are **wedged** and **cemented**.

This method of flashing is preferable to that last mentioned, since the lead is free at one edge.

111. **Gutters.**—Gutters are required to carry off the water which falls on a roof. There are several methods of forming them, depending largely on the position they occupy, whether at the eaves, behind a parapet, between two roof slopes, or at the back and sides of a chimney. Examples of each of these will be given.

112. **Eaves gutters** are usually of cast iron or zinc. The simplest form is the half circle iron gutter, or **rhone**, shown in fig. 201. They are cast in 6 feet lengths, with a **faucet** at one end of each. Into this faucet is laid the end of the next length (see figure), the joint being put together and made tight with **red lead**. A $\frac{1}{4}$ inch bolt and nut keeps the pieces in position.

These half-round gutters may be supported by wrought-iron hooks about $1\frac{1}{2}$ inch broad and $\frac{3}{16}$ inch thick, having a tail some 8 inches long either nailed or screwed to the woodwork of the roof (fig. 170).

Sometimes the gutter is carried by malleable iron hooks of

the form given in fig. 202. These may be driven into the joints of the brickwork. In fixing shallow gutters of this description, a considerable fall is required to get rid of the water quickly enough to prevent overflowing. Galvanised wire cones are usually laid in the **nozzles**, or outlets, of the gutters to prevent the down pipes becoming stopped up.

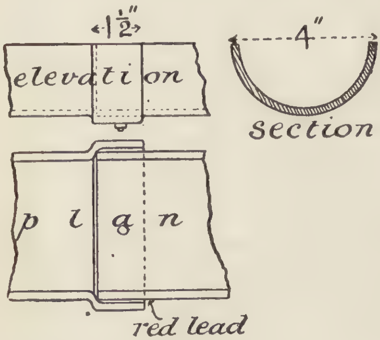


FIG. 201.


FIG. 202.

Ornamental cast-iron gutters may be obtained of almost any pattern. In fig. 167 an **ogee** gutter is shown resting on the top of the wall, and secured by screws to the woodwork of the roof. That illustrated in fig. 173 is carried entirely by the screws which fasten it to the fascia board. These **ogee** gutters are supposed to add a finish to the eaves, suggesting by their form a light stone cornice.

113. Lead gutters are laid on boards supported by **bearers.** When these bearers are **framed in** between the roof timbers, the gutter is termed a **trough** or **parallel gutter.** In some cases the bearers are simply **nailed to the rafters.** In this case it is known as a **V-gutter.**

When sheets of lead require to be joined at right angles to the length of a gutter, it is done in the manner indicated in fig. 203.

At intervals of about 10 feet, steps or **drips** are formed in the woodwork. These should not be less than 2 inches deep ; 3 inches is better. A rebate $1\frac{1}{2}$ inch wide is sunk along the edge of the upper boarding. The lower sheet is then dressed up against the step and into the rebate. In this way the upper sheet, when turned over the edge, will lie quite flat.

Some plumbers do not make use of the rebate, but cut off the sheet about ½ inch below the higher level.

Again, it is a common practice to dress the upper sheet over the step and an inch or so down on the lower gutter. There is no advantage to be derived from this. On the other hand, capillary attraction gets full scope, and the water is soaked up into the woodwork.

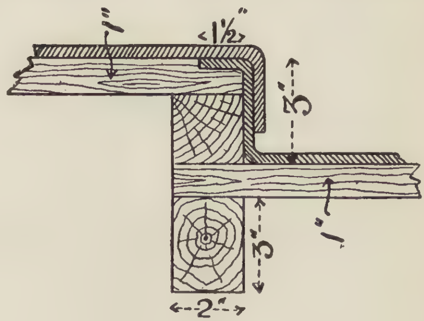


FIG. 203.

In very exposed situations the sheets of lead may be bent over together in the same way as the nosing in fig. 195.

114. V-gutters.—An example of a V-gutter formed between two roof slopes is shown in fig. 204.

The rafters are notched out so as to fit the wall plate. Between them are fitted the gutter bearers. These bearers might have been nailed **across** the rafters, as in fig. 178.

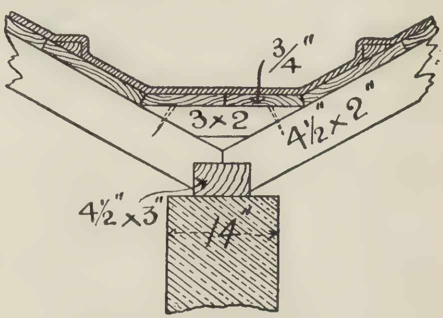


FIG. 204.

In order to obtain the necessary slope, the bearers must be fixed higher up or lower down the rafters, as the case may be. This has the effect of rendering the gutter unequal in width. The higher the bearer the wider the gutter becomes. It is, therefore, advisable to provide frequent **outlets** for the water, so that long lengths of gutter become unnecessary. The

lead is dressed over a tiling fillet, and well up the roof slope, on both sides.

In fig. 205 the V-gutter is formed in what is known as a **valley** between two roof slopes. The common rafters are nailed to a **valley piece**, and the lead is laid on the boarding without the intervention of bearers.

Drips are not required, as the inclination of the valley rafter itself is considerable. The sheets are joined by simply overlapping them 6 inches or so.

Valley gutters may be obtained in cast iron to suit various pitches.

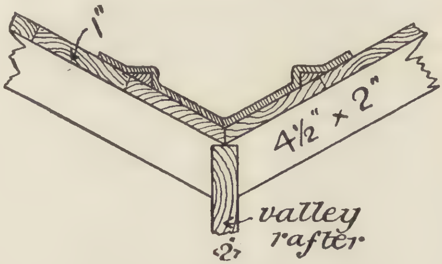


Fig. 205.

A V-gutter behind a parapet wall is shown in fig. 178, one end of the bearer being nailed to the rafter, and the other supported on a gutter plate.

Fig. 206 shows a V-gutter behind a chimney penetrating the roof. The construction is evident and needs no description. A plan of the roof timbers has been added in order to show the method of trimming the rafters round the chimney.

A section on the line *a b* is given in the next figure, the **slates** and **lead-work** being added to show the way in which the flashing is dressed **under** the slates so as to form a gutter down the side of the chimney. This is preferable to laying it **over** the slates.

It must be borne in mind that the **steeper** the roof, the **higher** the flashing must be behind the chimney to prevent splashing.

115. Parallel, trough, or box gutters.—Fig. 179 shows a gutter of this kind behind a blocking course

The bearers are supported at one end by a gutter plate, and at the other by the pole plate, into which they are framed.

The great advantage of this construction is, that lowering the bearers to secure a fall does not necessitate narrowing the gutter.

Instead of using only one width of lead, as shown, it may stop short half an inch below the tiling fillet, the portion lying

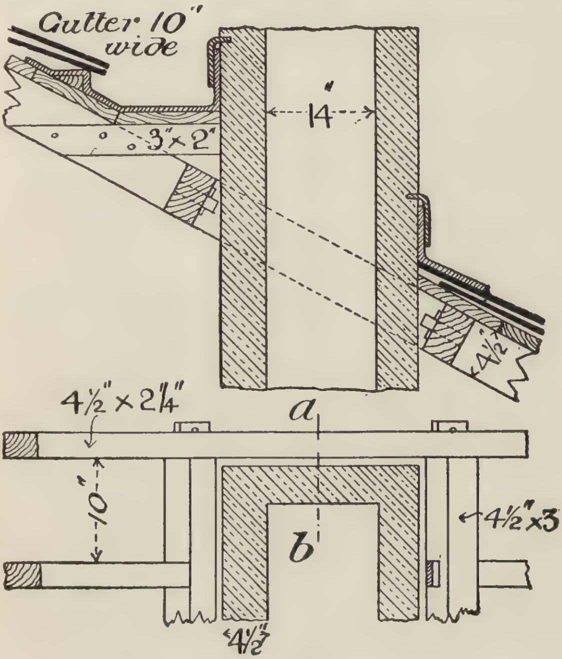


FIG. 206.

on the roof being dressed over so as to form an apron. The same method may be adopted on the other side of the gutter.

Both in V and parallel gutters care should be taken that the lead extends sufficiently up the roof to prevent the water, in case of choking, finding its way over the edge of the sheet into the woodwork of the roof. Overflow pipes are frequently inserted in the blocking course to avoid this. As soon as the

water rises to the level of these outlets, it runs off. The lead should be dressed up the roof slope until it exceeds the level of the overflow.

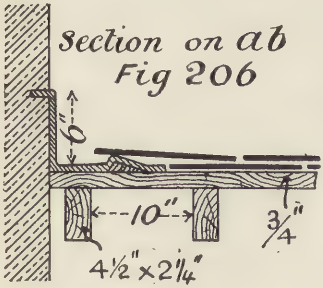


FIG. 207.

The water which ordinarily runs into the gutter is got rid of by means of **cesspools** or **drip-boxes** connected with the head of the rain-water pipe. These cesspools are wooden boxes sunk below the boarding the full width of the gutter, about 9 inches deep and 18 inches long, according to circumstances. They are lined with lead to within a short distance of the top. The edges of the gutter sheets are then dressed over in the form of aprons. The outlet is at the bottom of the box, and should be covered with a perforated rose, or grating, of sheet lead or zinc, to intercept rubbish which would otherwise find its way into the pipe and block it.

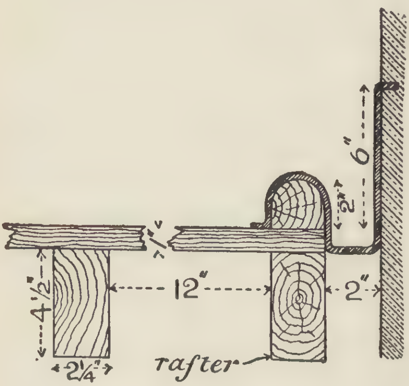


FIG. 208.

It will be well to note that valley and box gutters should always be of such width as will allow a man to walk along them without damaging the slates at the sides.

Secret gutters are used instead of flashing at the junction of a roof and chimney or two parts of a roof.

Fig. 208 shows a secret gutter in the former position. The rafter is kept about 2 inches away from the brickwork. Along the edge of the boarding is nailed a wood roll or triangular fillet. A sheet of lead is then dressed over the roll and formed

into a gutter. The upstanding edge should be turned into the wall as usual. Another plan would be to carry up the edge of the sheet only $3\frac{1}{2}$ or 4 inches and cover it with an apron secured in a raglet.

The lead must not be carried too far on to the roof, so as to be pierced and fastened by the nails holding the slates. These latter may be laid quite over the gutter up to the wall. This is not shown in the figure. In practice secret gutters are objectionable. They get choked, and gradually silted up with leaves and dirt.

For all the purposes mentioned in this chapter to which lead is applied, sheet zinc is now frequently used. For flashings, gutters, etc., lead is, however, preferable.

The modern 'jerry builder' is, nevertheless, quite independent of either of these materials for securing the joints between walls and roofs. A **fillet of cement** or even **coarse stuff** (lime and hair) run along the angles is considered by him to be ample protection against the weather.

It is unnecessary to add the result of this inferior work.

Exercises on Chapters VIII. and IX.

1. Draw figs. 190 and 191 to a scale of $\frac{1}{6}$, adding in each case a section on the line *a b*.

2. Sketch freehand the forms of ridging shown in fig. 192.

3. Draw to scale, full size, the sections of lead rolls, and nosings, shown in figs. 193, 194, and 195.

4. Draw the ridge given in fig. 196 to a scale of $\frac{1}{2}$, adding countess slates, and lead ridge covering secured by lead-headed nails.

5. Draw fig. 199 to a scale of $\frac{1}{8}$, showing all the details of the lead and slate work, the step flashing shown in fig. 200 to be used.

6. Section of a drip, fig. 203. Draw to a scale of $\frac{1}{2}$.

7. Draw figs. 204 and 205 to a scale of $\frac{1}{4}$, adding in the first example a plan, and in the second, details of the slate work.

8. Horizontal and vertical sections through a brick chimney penetrating a roof. Draw to a scale of $\frac{1}{4}$.

9. Draw the section on *a b*, fig. 206, to a scale of $\frac{1}{3}$, showing the lead work and slates.

10. Section through the rafters of a roof showing a secret gutter at the intersection of a chimney with the slope. (Fig. 208.) Draw to a scale of $\frac{1}{3}$, showing slates laid quite over the gutter and an apron turned down over the side of the upstanding gutter sheet.

11. Side and front elevations of the common rafters of a roof to be covered with countess slates 20″ × 10″ on battens, fig. 209 (*a*). Draw to a scale of 2′ to 1″ and show the arrangement of the slates and battens to a 3″ lap, with position of nails both in section and elevation.

12. Plan of a lean-to roof covered with countess slates, fig. 209 (*b*). Give sketch of the section on A A, marking on the parts their names and showing the lead, slate, brick, and woodwork complete.

13. Section of 9″ × $\frac{3}{4}$″ roof boarding on rafters, fig. 209 (*c*). Draw to a scale of 1″ to one foot, adding countess slates laid to a 4″ lap and centre nailed.

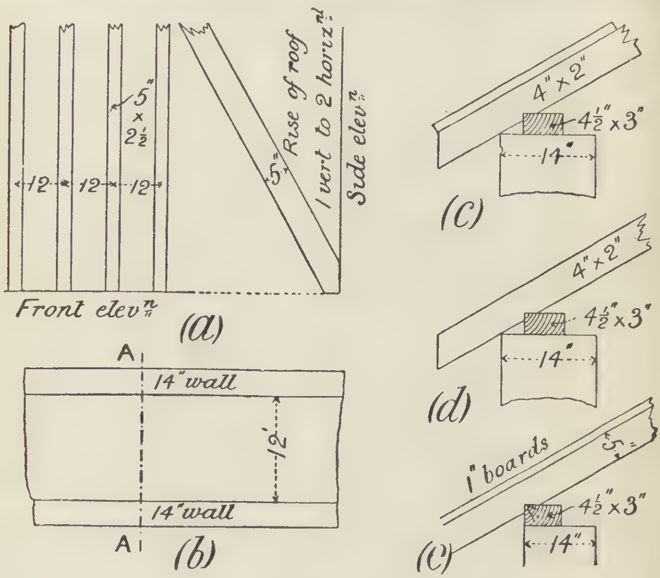


FIG. 209.

14. A section at the eaves of a roof covered with countess slates 20″ long, fig. 209 (*d*). Draw to scale of $\frac{3}{4}$″ to a foot, adding the first four courses of slates.

15. Section at the eaves of a roof, fig. 209 (*e*). Draw to a scale of 1½″ to 1′, adding a tilting fillet, and duchess slates 24″ × 12″ laid to a 4″ lap. Explain the object of the tilting fillet.

16. Elevation of a brick chimney shaft running through a roof, fig. 210 (*a*). Draw to a scale of ½″ to a foot, marking the joints of the brick-work by single lines and adding step flashing.

17. Section through the gable end of a slate roof, showing a brick parapet with stone coping, common rafters, and slate boarding, fig. 210 (*b*).

Draw to a scale of $\frac{1}{12}$, adding countess slates and lead flashing to keep the weather out.

18. Sectional elevation of the eaves of a roof, the trusses being 10′ apart, fig. 210 (*c*). Draw to a scale of $1\frac{1}{2}''$ to a foot, adding countess

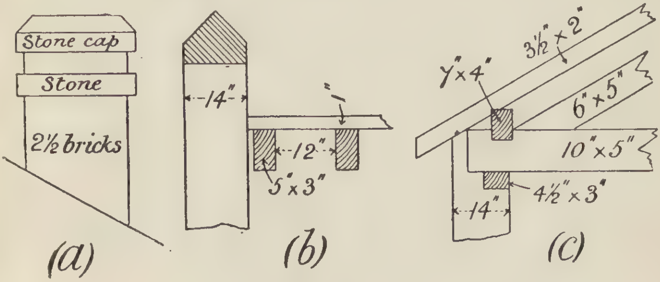


FIG. 210.

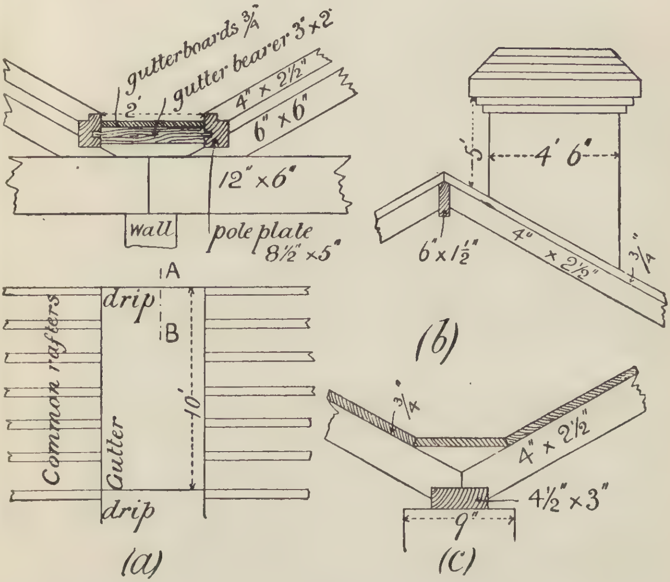


FIG. 211.

slates laid to a 3″ lap on battens, fascia, and soffit boarding, with cast-iron ogee gutter; also plastered ceiling below tie beam.

19. Plan and section of the middle gutter of a double roof, fig. 211 (*a*).

Draw the section given to a scale of 1″ to 1′ and give on same scale a section on A B, showing the lead in both sections and how it is kept in place.

20. Sectional elevation through a roof showing chimney shaft, fig. 211 (*b*). Draw to a scale of ½″ to 1′, add slating with countess slates 20″ × 10″ laid to a 3″ lap and with the nail holes at a distance of 1′ from the bottom of the slates; also add lead flashing with joints and slate ridge, showing mode of fixing.

21. Section of a gutter of a double roof, fig. 211 (*c*). Draw to a scale of 1″ to a foot and add lead and slating (countess slates 20″ × 10″ with a

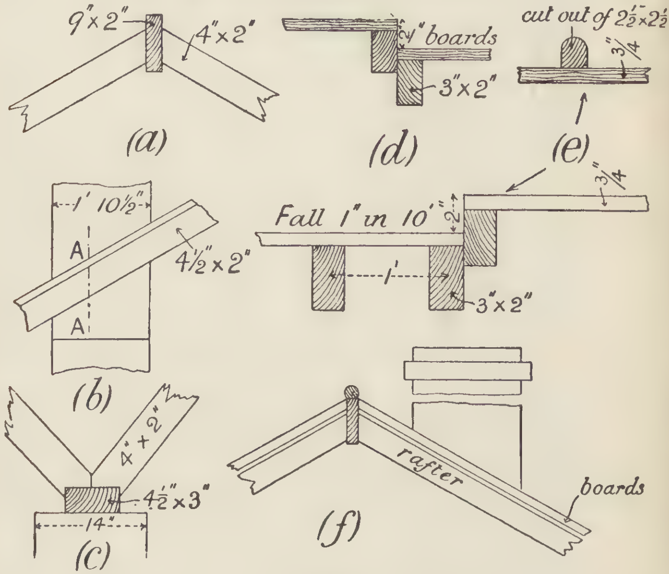


FIG. 212.

3 lap), the lead to be shown by a thick line and the slating by thin lines on the right side of the figure.

22. Ridge board and rafters of a roof, fig. 212 (*a*). Draw to a scale of ¾ of an inch to a foot, showing 4 rows of countess slates centre nailed to ¾″ battens; also a lead ridge roll.

23. Elevation of the end of brick chimney shaft, with section through part of the adjoining roof, showing slate boarding and rafter, fig. 212 (*b*). Draw to a scale of 1½″ to 1′, adding 20″ countess slates laid to a 3″ lap with step flashings, etc. Give a section of the same through A A.

24. Common rafters resting on a wall between two roofs, fig. 212 (*c*).

Draw to a scale of 1″ to one foot, adding a lead gutter laid on 1″ boards and 3″ bearers; also show four courses of countess slates 20″ × 10″ laid to a 3″ lap and centre nailed to $2\frac{1}{2}$″ × $\frac{3}{4}$″ battens.

25. Section through a drip for a lead gutter, fig. 212 (*d*). Draw $\frac{1}{3}$ full size and add the lead.

26. Sections of drip in gutter, and roll on flat roof, at a joint in the lead covering, fig. 212 (*e*). Draw to a scale of $\frac{1}{3}$ full size and add lead in each case.

27. Sectional elevation through a roof, showing chimney shaft, fig. 212 (*f*). Draw and add lead ridge and flashing.

28. Section at the eaves of a roof, fig. 213. Draw to a scale of $\frac{1}{8}$, adding countess slates 20″ long and a lead gutter.

29. Draw to scale of $\frac{1}{24}$ a king post roof truss of 20′ span in the clear, with walls 14″ thick, to the following dimensions:—

Principal rafters, 5″ × 4″; tie beam, $9\frac{1}{2}$″ × 5″; struts, $3\frac{1}{2}$″ × $2\frac{1}{2}$″; king post, 5″ × 3″; ridge board, 8″ × $1\frac{1}{2}$″; purlins, 8″ × 5″; pole plates,

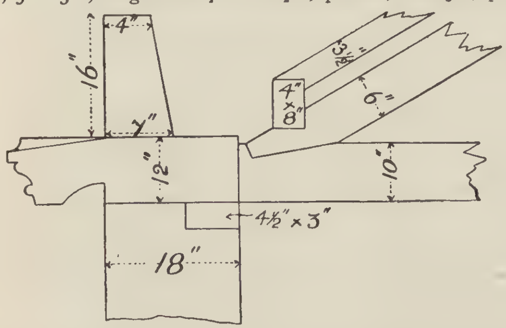


FIG. 213.

8″ × 5″; common rafters, 4″ × 2″; slate boards, $\frac{3}{4}$″ thick, eaves to project 18″ beyond wall; wall plates, $4\frac{1}{2}$″ × 3″; rise of roof, $\frac{1}{4}$ span. Add countess slates, 20″ × 10″, lap 3″, the nail holes on the slate being at a distance from the bottom of the slates equal to the gauge + the lap + half an inch.

30. Give sections, $\frac{1}{2}$ full size, through: 1st, a 2″ roll joint on a lead gutter, the lead resting on 1″ gutter boards carried on 3″ × 2″ bearers; 2nd, a drip in the same gutter.

31. Show by sketches what would be the result of laying slates without any tilting fillet, and show how a fascia board can be utilised in place of a tilting fillet.

32. Give sections half full size showing a 2″ drip in a lead gutter and a $2\frac{1}{2}$″ roll on a lead flat.

33. Give an elevation to a scale of $\frac{1}{2}$″ to one foot of a chimney shaft

rising through the centre of a roof at right angles to the ridge. Show on the right of the ridge, lead flashings as applied to a brick shaft, and on the left to a stone shaft, the shaft to be 7′ 3″ wide.

34. Give a vertical cross section to a scale of ½″ to one foot through a brick chimney shaft 32″ wide from out to out and 14″ from in to in, showing how the common rafters are trimmed and the lead gutter formed at the back of the shaft, rafters to be 4″ × 2″, and trimmer 4″ × 3″, slates and slate boarding to be shown.

CHAPTER X.

DOORS.

116. General remarks.—Doors are named from the manner in which they are constructed or the number of panels they contain.

Thus we have :—

(1) Ledged doors.
(2) Ledged and braced doors.
(3) Framed and ledged doors.
(4) Framed, ledged, and braced doors.
(5) Four-panelled doors.
(6) Six-panelled doors.
(7) Double margined doors.
(8) Folding doors.
(9) Sash doors.

Doors are of various widths and heights, depending, of course, on the position occupied. External doors should, as a rule, be **wider** than those for internal work. The minimum width of any door should be 2 feet 6 inches, and the height 6 feet 6 inches.

If a door is required to be more than about 3 feet 6 inches wide, it is usual to hang it in two leaves, as in fig. 235. It thus becomes less inconvenient to open, and the space necessary for it to swing in is not so large.

The doors illustrated in this chapter are, with the exception of that shown in fig. 223, all hung in **solid frames.** These frames consist of two uprights or **posts** tenoned at the top into

a cross piece or **head**. The feet of the posts are mortised into the **threshold** or **sill**.

In constructing a solid door frame the head is sometimes allowed to project beyond the posts. These projections or **horns** serve to keep the frame firm in the brickwork. Usually the door frame fits into a recess in the wall and is nailed to **wood bricks, plugs,** or **pallets.**

In the case of internal doors it is sometimes necessary to fix the frame inside the jamb **without any reveal,** as in fig. 236. The same plan is often adopted for external doors in common work.

A rebate should be run along the inside edge of the frame into which the door may fit.

To save material and labour, a wood **slip** or **fillet** is frequently nailed to the frame instead of forming a rebate. Outside doors are generally hung so as to open inwards. Inside doors should open away from anyone entering the room, and must be hung so as to protect the room as much as possible from draughts, when open. In bedrooms the doors should, when open, screen the position of the bed.

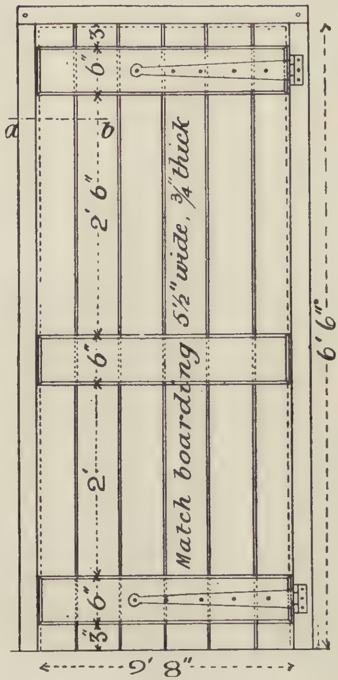


FIG. 214.

117. Ledged doors.—The simplest form of door consists of vertical **boards** or **battens** nailed to cross pieces termed **ledges**. In the commonest work the boards are simply planed square at the edges and butted one against the other. The example of a ledged door given in fig. 214 has the boards

grooved, beaded, and tongued. This is known as **match-boarding**.

The door referred to is made to open inwards and the rebate in the frame is $2\frac{1}{4}$ inches deep, so that when closed the ledges are **flush with the frame.**

Sometimes the rebate is only cut deep enough to take the boarding. In this case the ledges stand beyond the frame.

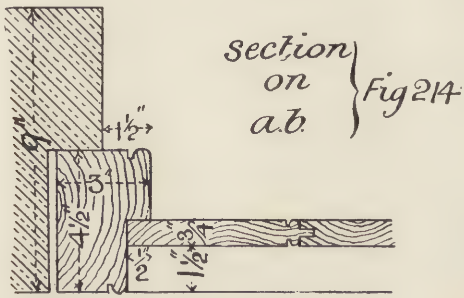


FIG. 215.

Consequently, the hinges must be screwed to wood blocks firmly fixed to the posts.

The section given in fig. 215 shows the edges of the frame beaded : this adds to the appearance of the work.

118. Ledged and braced doors.—Fig. 216. The introduction of **diagonal braces** renders this construction superior to the preceding. It should be noticed that these braces cross the back of the door from the outer edge to that by which it is hung to the frame. By this means the weight of the door is thrown more directly on the joints. The further the weight acts from these points, the greater tendency has it to produce sagging.

The ends of the braces are cut obliquely, the ledges being notched out to receive them.

In the example given, the edges of the braces and ledges are **bevelled** off. Sometimes they are **beaded, stop chamfered,** or even left **square.**

The ledges are here shown the full width of the door. If the latter is to open outwards, the frame would have to be

recessed to receive the ends of the ledges. This may be avoided by making them shorter, so as to clear the rebate.

In putting together a door of this kind the boards are first nailed to the ledges. Then the braces are inserted, and secured in the same way to the boarding.

119. Framed and ledged doors.—We now come to consideration of doors consisting of an **outer framework** strengthened by one or more cross pieces or **rails**, the remaining portions being filled in with boards.

The simplest construction of this kind requires two vertical pieces or **stiles**, with top, middle or lock, and bottom **rails** ten-

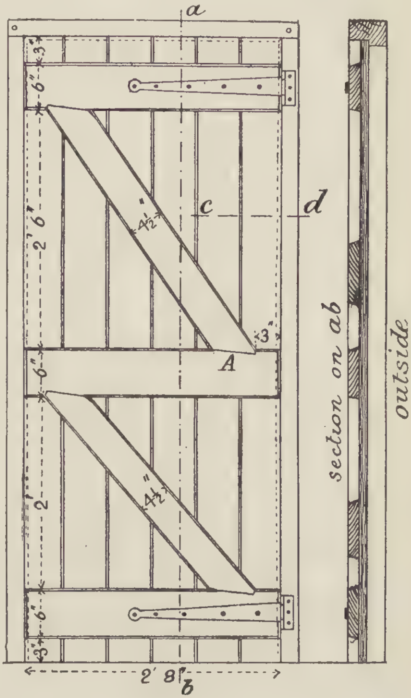


FIG. 216.

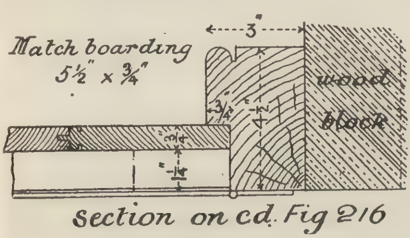


FIG. 217.

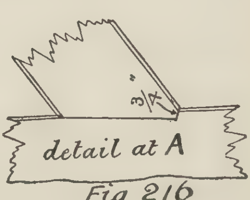


FIG. 218.

oned into them as shown in fig. 219, the details of which resemble those given in the succeeding diagrams.

M

In the example taken, the matchboarding runs from the lower edge of the top rail to the upper edge of the bottom rail, being grooved into them and also into the stiles. As the boarding is flush with the outer face of the framework, the lock rail must be thinner than the rest of the framing.

Fig. 219.

120. Framed, ledged, and braced doors.—An inside elevation of one of these is shown in fig. 220. The framework is constructed in the same way as that in the last example, with the addition of diagonal braces.

These are shown butting partly on the rails and partly on the stiles. Some object to this and prefer to keep the braces clear of the stiles altogether, alleging that the tendency of the braces when in the former position is to drive the stiles off the rails.

The matchboarding is ploughed, tongued, and V-jointed on both sides, and runs from the under edge of the top rail quite to the ground, thus hiding the lower rail, which in this case must be of the same thickness as the lock rail.

For outside doors this is an advantage, since the rain does not then lodge in the joint between the boarding and the bottom rail.

The thickness of the bottom rail, lock rail, and braces is equal to that of the stiles and top rail minus the thickness of the matchboarding. The inner edges of the framing are shown **stop chamfered.**

Fig. 221 is a detail of the joint at A.

The top rail has a single **haunched tenon** at each end, wedged and glued into a mortise cut through the style.

The upper end of the brace has the horizontal part halved

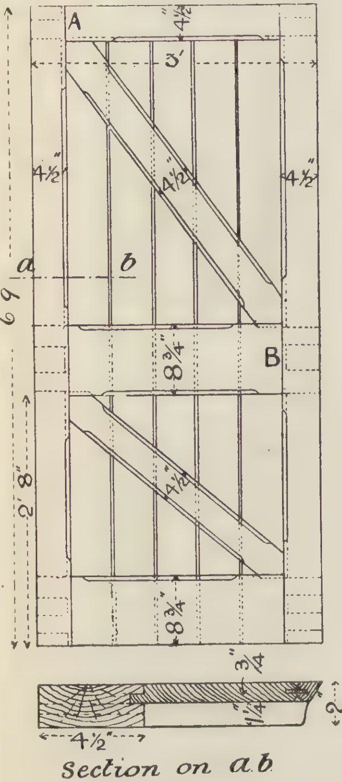


FIG. 220.

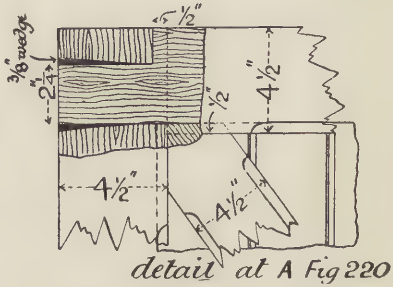


FIG. 221.

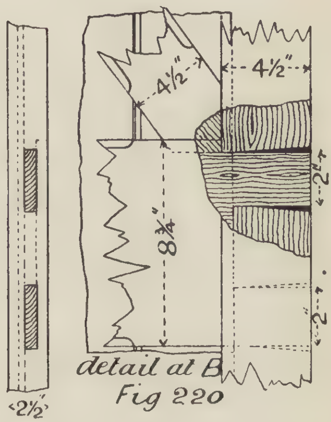


FIG. 222.

into the top rail from the front of the door, the vertical portion simply butting against the stile.

A detail of the joints between the lock rail, stile, and upper brace is given in fig. 222. This is similar to that last described, with the exception that a **double tenon** instead of a **single tenon** is cut on the end of the lock rail.

One point with respect to these tenons should be noted.

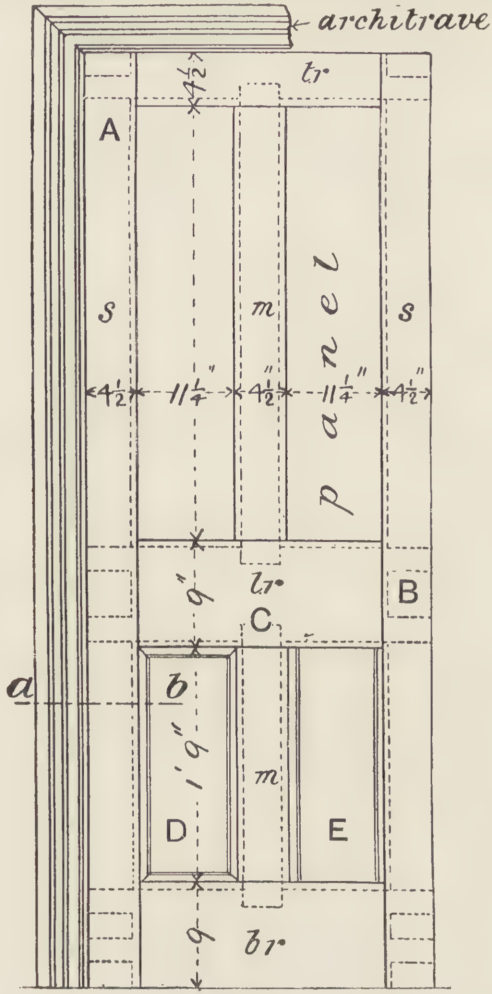


FIG. 223.

Since the lock rail is **thinner** than the stile, the tenons on the former will not come in the middle of the thickness of the

latter. In order to keep the mortises as near as possible in the centre of the stile, the tenons are made **barefaced**—i.e. are cut flush with the inner face of the rail instead of in the middle of its thickness, as is the case with the top rail. The same remark applies to the tenons of the bottom rail. The edge elevation given in fig. 222 will render this construction clear.

This door is put together in the following way :—

(1) The rails are fitted into the stiles.

(2) The braces are dropped into position from the face of the work.

(3) The matchboarding is slipped into position.

(4) The parts are driven tightly together, the tenons wedged and the boarding nailed to the rails and braces.

121. Panelled doors.—A framed door with four panels is shown in fig. 223. It is made up of the following parts :—

(1) **Two outer stiles.**

(2) **Top, lock** (middle), and **bottom rails** tenoned into the styles.

(3) **A centre stile** or **munting** in two portions, framed in between the rails.

(4) **Two upper** and **two lower panels** grooved into the rails, munting, and stiles to a depth of about $\frac{1}{2}$ inch.

In putting these parts together the stiles are left till the last, being driven on the tenons and tightly wedged up after all the other pieces are in position.

The framework of a panelled door is the **same thickness throughout**.

When the door is very high there are frequently **six** panels. This necessitates the addition of a **frieze** rail between the top and lock rails. The two top panels in this case are termed **frieze panels.** It should be noticed, that whatever the number of panels may be, the **rails are continuous.** It is the **munting** which is **divided** and tenoned into the rails, not the rails into the munting.

The section given in fig. 224 shows the method of hanging internal doors to the **jamb casing** or **lining**, instead of using a solid frame. The lining is rebated either on one or both edges, so as to form a **stop** for the door, and is nailed to **wood**

blocks, plugs, or **pallets,** built into the brickwork. These blocks, etc., should be placed so that the hinges may be screwed **through** the casing into them. This is not always done. The consequence is that the screws, having only the thin lining in

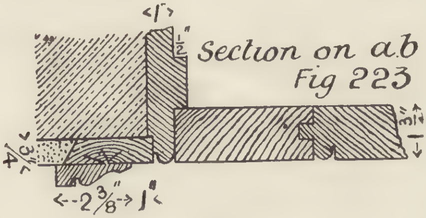


FIG. 224.

which to hold, frequently break away. The edge of the lining is shown beaded and rebated to receive **the ground,** which is a strip of wood nailed down the edge of the wall face and bevelled off to form a key for the plaster. The joint between the ground and plaster is covered by the **architrave** which is nailed to the former.

Sometimes the architrave is brought forward so as to just cover the joint between the ground and lining. When this is the case, the latter need not be rebated to receive the ground.

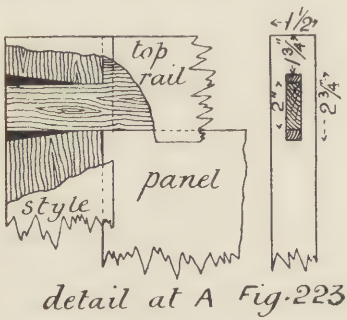


FIG. 225.

Fig. 225 shows the method of grooving the panel into the top rail and style.

The student's attention is directed to the end views of the lock rail in fig. 226. The first of these shows two tenons, situated in the middle of the thickness of the rail. In the other, four tenons are cut instead of two, leaving a clear central space the full depth of the rail. This is convenient when a mortise lock has to be inserted, and obviates any cutting of, or interference with, the tenons, when forming the

mortise in the style for its reception. This would not be the case if the tenons occupied a central position.

The muntings are tenoned into the rails as illustrated in fig. 227.

122. Panels are thin pieces of wood used to fill in the openings of door framing, etc. The materials now generally used are mahogany, white wood, and other hard woods. These can be procured in fair widths and are almost as cheap as pine, and infinitely better.

If the openings are wide, it is not always possible for the panel to be in a single piece. When the stuff is very thin, the vertical joint should be plain, a piece of canvas being frequently

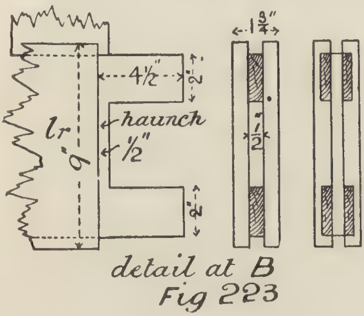


FIG. 226.

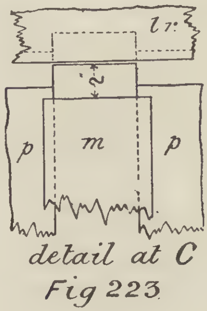


FIG. 227.

glued on one side of the panel to keep the pieces from separating. In other cases it is better to form a ploughed and tongued joint.

Panels are sunk in grooves cut along the inner edges of the framework. The edges of the panels should be **clear of the bottom of the groove**. The thin stuff of which they are made is very liable to expand if subjected to a moist atmosphere, and unless room is allowed for this expansion the panel will **warp** and **buckle.**

The following terms are applied to the different kinds of panelling in common use :—

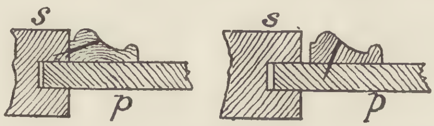
(1) Square and flat.
(2) Moulded and flat.

(3) Flush.
(4) Solid.
(5) Bead butt.
(6) Bead flush.
(7) Raised.

123. **Square and flat panels** are of the same thickness throughout, usually about $\frac{1}{3}$ that of the framing. The term square really applies to the stile, and signifies that its edges are not ornamented with beads or mouldings. It will be as well to note that, although in the present day mouldings are nearly always **planted** on the edge of the stile, yet the notion intended to be conveyed is that they are worked on the style itself.

The upper panels of the door in fig. 223 are square and flat.

124. **Moulded and flat panel.**—The panel is flat, as in the last case, but is ornamented by a moulding, either



FIGS. 228 and 229.

worked on the framing itself or stuck on its inner edge. This may be done on one or both sides of the panel. Fig. 237 shows a panel flat and moulded on both sides.

Fig. 230 shows the section of a panel of similar description. The elevation indicates the manner in which the mouldings are **mitred** at the angles. The large, bold moulding shown in the section at the back of the panel is termed a **bolection.**

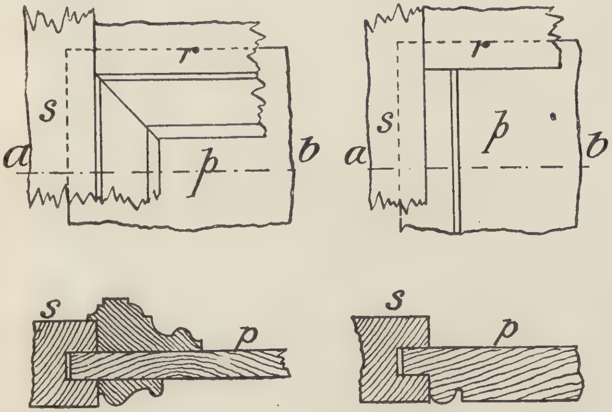
With regard to fixing the moulding, it should be noted that, if nailed to the panel itself, the latter, when it shrinks, will bring away the moulding from the edge of the frame, fig. 229. It should, therefore, be secured by means of brads to the **inner edge** of the frame. This is illustrated in fig. 228.

125. **Flush panels** have one or both surfaces in the same plane as the face of the framework.

Fig. 231 gives a section of a panel flush on one side and ornamented by a bead stuck on the panel itself. The panel in

fig. 232 is flush on both sides, the edges being **chamfered** on one side and **beaded** on the other.

126. Solid panels are formed in one piece the full thickness of the framework.



FIGS. 230 and 231.

127. Bead butt panels are chiefly used in common work. Beads are run up the vertical edges **only** of the panels, as shown in fig. 231. Panel E, fig. 223, is bead-butt.

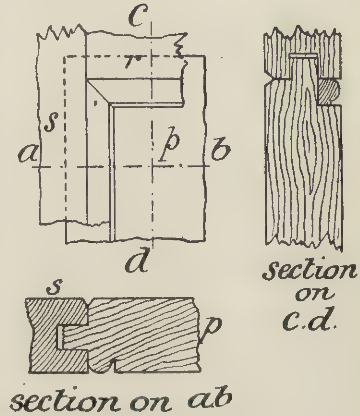


FIG. 232.

128. Bead flush panels have the bead worked round all the edges. The vertical portions are generally stuck on the edge of the panel itself. The horizontal beads are with difficulty cut across the grain of the panel, and are therefore occasionally stuck on the edge of the rail.

The more common practice, however, is to make them in

separate strips, which are then nailed in grooves cut along the upper and lower edges of the panels. A reference to fig. 232 will make this clear.

129. Raised panels.—The term **raised** signifies that the

FIGS. 233 and 234.

panel is not the same thickness throughout. The central portion projects above the rest, the edges of the panel being thinned down so as to fit the grooves in the framework.

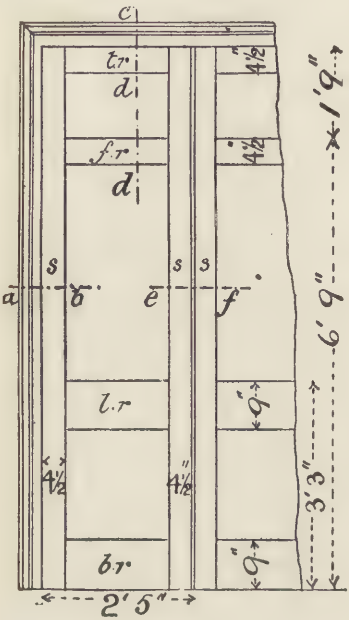


FIG. 235.

Fig. 233 shows this in section, the back of the panel being flat and moulded. The edges of the panel are frequently ornamented with a moulding, as are also the edges of the raised portion.

Fig. 234 is a section of a moulded and flat panel. The moulding in this case is stuck on the frame. Its form is known as the **cyma recta**—the 'lamb's tongue' of the joiner.

130. Double margined doors.—When an ordinary door is required to be very wide it may be constructed so as to resemble one hung in two parts (see fig. 235). The door is first made in two separate leaves, which are afterwards secured together with several pairs of **fox-wedges**, or **keys**.

131. Folding doors.—An elevation of a pair of folding doors is given in fig. 235. The panels are all shown square and flat.

Figs. 236, 237, and 238 are horizontal and vertical sections on the lines *a b*, *c d*, and *e f*. Fig. 237 shows the method of forming a tight joint between the meeting stiles.

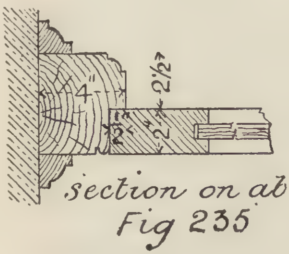


FIG. 236.

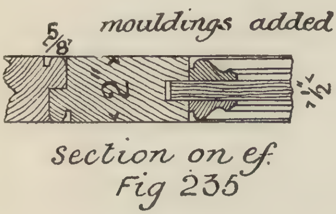


FIG. 237.

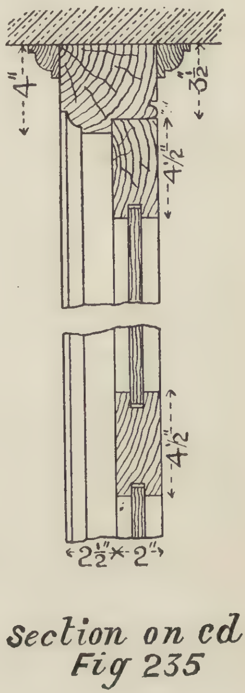


FIG. 238.

132. Sash doors.—Fig. 239 shows a door in which the upper panel is of glass. This is termed a **sash door.**

In order to allow as large a space as possible for glazing, the styles are cut back, or **diminished** as it is termed, at the lock rail. Fig. 240 illustrates the necessary modification of the tenons at this point. A horizontal section on the line *a b* is given in fig. 241, to show the method of securing the glass. A

bead is first nailed round the inner edge of the frame. The sheet of glass is then inserted and kept in position by another bead nailed close up to it.

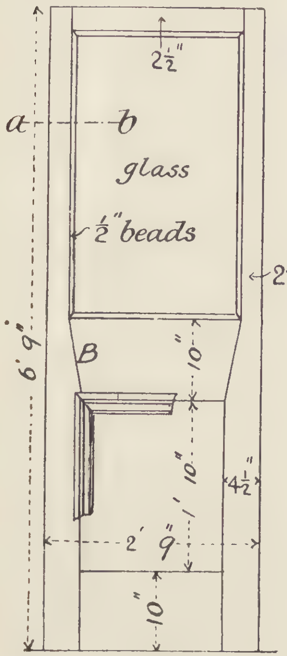


Fig. 239.

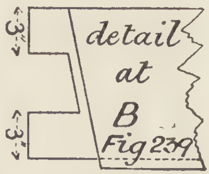


Fig. 240.

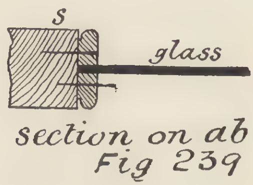


Fig. 241.

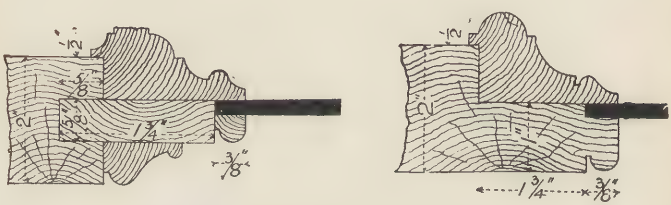


Fig. 242.

In the same figure is shown an alternative and better method of fixing the glass. Instead of planting a bead along

the edge of the stile to serve as a backing for the glass, a rebate is cut as indicated, to serve the same purpose.

In doors of a superior description the stile is sometimes grooved and a strip of wood driven in, fig. 242. On one side of this strip a **bolection moulding** is planted. The edge of this moulding projects beyond the slip and forms a bed for the glass, which is fastened in its place by a bead nailed along the inner edge of the strip. Another method of construction is given in the same figure.

It may here be mentioned that in superior work the glass is usually embedded in chamois leather, and is thus less liable to fracture from any jarring of the door.

Exercises on Chapter X.

1. Elevation of a common ledged door, fig. 214. Draw to a scale of $1\frac{1}{2}''$ to one foot, showing also a section on the line *a b*, $\frac{1}{3}$ full size.

2. Give to a scale of $\frac{1}{8}$ a vertical section of the door shown in fig. 214.

3. Draw fig. 216 to a scale of $\frac{1}{8}$ and add an elevation of the front of the door.

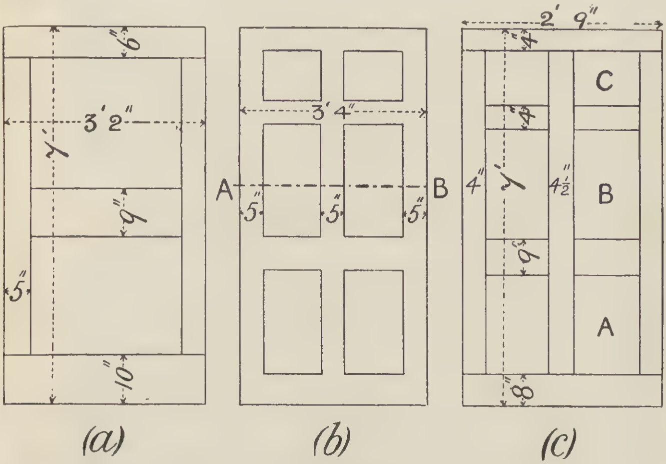


Fig. 243.

4. Draw to a scale of $\frac{3}{4}$ the section given in fig. 217.

5. Elevation of the back of a framed and ledged door, fig. 219. Draw to the following dimensions and add a horizontal section on a line 18′

above the middle rail: Height of door, 6′ 9″; breadth, 3′; thickness, $2\frac{1}{4}$″; bottom rail, 9″ deep; lock rail, 9″; top rail, $4\frac{1}{2}$″; stiles, $4\frac{1}{2}$″ wide; match-boarding, $5\frac{1}{2}$″ wide and $\frac{3}{4}$″ thick; lower edge of lock rail, 2′ 9″ above the ground.

6. Elevation of the back of a framed, braced, and ledged door, fig. 220. Draw to a scale of $\frac{3}{4}$″ to one foot. The section on *a b* is to be drawn $\frac{1}{2}$ full size.

7. Draw the details in figs. 221 and 222 to a scale of 6″ to one foot.

8. Draw to a scale of $\frac{1}{8}$ the four-panelled door shown in fig. 223, giving separate details of the joints at A, B, and C to a scale of $\frac{1}{4}$, the upper

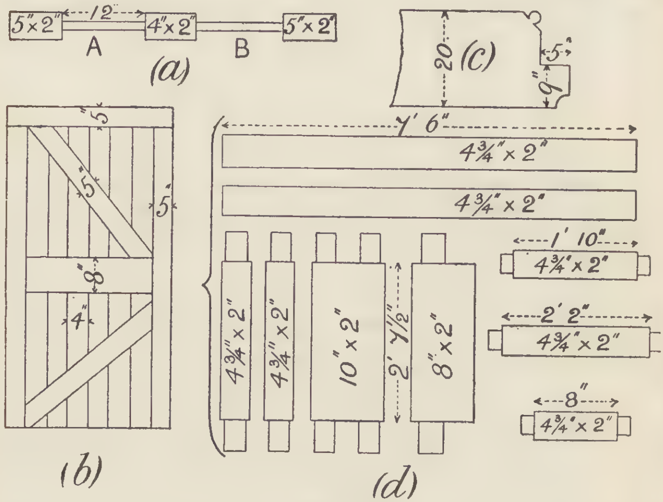


FIG. 244.

panels to be moulded on both sides, the lower bead flush on one side, and square and flat on the other.

9. Give $\frac{1}{8}$ full size a vertical section of the door mentioned in the preceding exercise, the panels to be moulded on both sides.

10. Draw figs 224, 225, 226, and 227 to a scale of $\frac{1}{3}$.

11. Elevation of a pair of folding doors, fig. 235. Draw to a scale of $\frac{1}{12}$ the panels to be moulded on both sides. Add complete sections on the lines *a b*, *c d*, and *e f* to a scale of $\frac{1}{2}$.

12. Elevation of a sash door with diminished stiles, fig. 239. Draw to a scale of $\frac{1}{8}$, adding to the same scale a vertical section on the centre line and horizontal sections through upper and lower panels. The lower panel has a bolection moulding on one side and is bead-flush on the other.

13. Elevation of the back of a framed and braced door filled in with

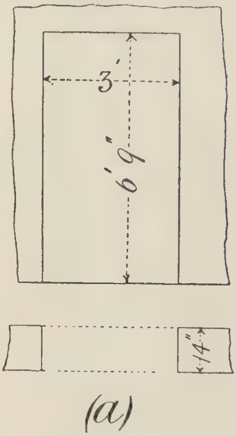
5″ battens, fig. 243 (*a*). Draw to a scale of $\frac{1}{24}$, making any additions and alterations you may consider necessary.

14. Elevation of an outer door $2\frac{1}{2}''$ thick, framed and panelled, moulded outside and bead-flush inside, fig. 243 (*b*). Give a section through A B to a scale of 1″ to a foot.

15. A six-panelled door, fig. 243 (*c*). Draw to scale of $1\frac{1}{2}'$ to an inch, making any alterations you may think necessary. The panel A to be bead-butt, the panel B to be bead-flush, and the panel C to be moulded. Show the tenons by dotted lines and write their names on the different parts.

16. Horizontal section through a door, fig. 244 (*a*). Draw to a scale of $1\frac{1}{2}''$ to a foot, showing the panel at A bead-flush on one side and square and flat at the back, and at B filled in solid.

17. Elevation of the back of a framed and braced door, fig. 244 (*b*).



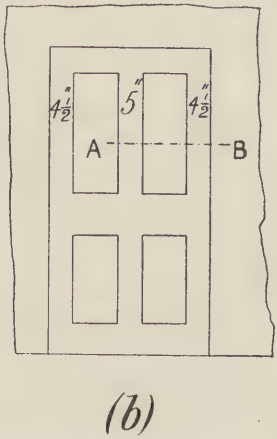


Fig. 245.

Draw to scale of 2′ to an inch, making any additions and alterations you think necessary. Write the names on the several parts.

18. Horizontal section through the jamb of an outer door. Draw to a scale of $\frac{1}{2}''$ to one foot, adding a solid door post $6'' \times 5''$, rebated and chamfered; also a small portion of the door, showing the stile $2\frac{1}{4}'' \times 5''$ with chamfered edges and a $\frac{3}{4}''$ panel flat both sides.

19. The figures given for this question are the different parts of the framing of a 2″ six-panelled door, showing the tenons but not the mortises or plough grooves for panels, fig. 244 (*d*). Put them together to a scale of $\frac{3}{4}''$ to one foot and write the names on them.

20. Horizontal section and elevation of an interval doorway, fig. 245 (*a*). Draw the horizontal section to a scale of 1″ to 1′, add section of

plaster linings and panelled door with architraves. Draw the elevation to a scale of $\frac{1}{2}''$ to a foot and add a six-panelled door, marking the names on each part and showing the visible joints; also draw the architraves.

21. Elevation of an interval doorway in a lath and plaster quartered partition, fig. 245 (*b*). Give a section through A B to a scale of $2''$ to a foot, showing a $2''$ door with moulded panels and architraves, the door stud to be $4'' \times 4''$ and the quarters $4'' \times 2''$, only one of which need be shown.

22. Draw to a scale of $\frac{3}{4}''$ to a foot an internal elevation of a $2\frac{1}{4}''$ framed and braced door $3' \times 7'$ and hung to a solid frame. Write the names and scantlings of the different parts against them.

23. Draw to a scale of $\frac{1}{2}''$ to one foot the back elevations of both a ledged door and a framed and braced door to be $7' \times 3'$ and put together in batten widths.

24. Give a vertical section to a scale of $\frac{1}{12}$ through the panels of a $6'\ 9''$ door framed as follows: $2''$ deal, four panels, bead flush at bottom, moulded and flat at top, and square and flat at back, top rail to be $5''$, lock rail $10''$, and bottom rail $9''$.

25. Give a horizontal section to a scale of $1\frac{1}{2}''$ to a foot through one side of an entrance doorway in a $14''$ brick wall, showing the frame beaded and rebated for a $2\frac{1}{2}''$ door and flush with the internal plastering, the joint between the plaster and the frame being covered with an architrave moulding.

26. The finished scantlings of the parts of a $2''$ deal six-panelled door are as follows: Stiles $4'' \times 1\frac{3}{4}''$, two rails $4'' \times 1\frac{3}{4}''$, one rail $8\frac{3}{4}'' \times 1\frac{3}{4}''$, one rail $9\frac{1}{2}'' \times 1\frac{3}{4}''$, muntings $4'' \times 1\frac{3}{4}''$. Draw in elevation to a scale of $1''$ to $1'$, showing two panels square, two moulded, one bead and butt, and one bead and flush, door $7' \times 3'$.

27. Give elevation and a vertical section to a scale of $\frac{3}{4}''$ to a foot, showing the framing of a $2''$ framed and braced door filled with $1''$ battens, narrow widths, the dimensions of the finished parts being as follows: Stiles $7' \times 6''$, top rail $2'\ 3'' \times 6''$, lock rail $2'\ 3'' \times 8''$, bottom rail $2'\ 3'' \times 10''$ (the lengths of rails are given between shoulders of tenons), braces $4''$ wide. Show position of lock and hinges.

28. Give a horizontal section to a scale of $2''$ to a foot through one side of an external doorway $4'$ wide in an $18''$ wall with $9''$ reveals, the section to show one leaf of a $2''$ double-hung door framed in panels, bead-flush on inside and moulded on outside, cement linings to jambs, finished with an angle fillet and $1\frac{1}{4}''$ staff bead.

29. Draw a horizontal section to a scale of $\frac{1}{8}$ through one jamb of a $3'$ doorway in a $14''$ brick wall, showing a $4\frac{1}{2}''$ reveal and the bricks laid in Flemish bond, a solid frame $5'' \times 4\frac{1}{2}''$ rebated and chamfered, and about half the door, which is to be framed and braced, with $5'' \times 2''$ hanging stile and $4\frac{1}{2}'' \times \frac{3}{4}''$ battens.

30. The finished scantlings of the parts of a framed and braced deal

door 7 feet by 3 feet 8 inches, filled in with inch battens ploughed, tongued, and beaded, are as follows: Stiles $6'' \times 2''$, rails $6'' \times 2''$, $8'' \times 1''$, $8'' \times 1''$, braces $6'' \times 1''$, battens 6 in number. Give a half elevation of the inside and a half elevation of the outside, showing any hidden joints by dotted lines. Scale $\frac{1}{24}$.

CHAPTER XI.

WINDOWS.

133. General remarks.—Windows are required either for **light** or **ventilation**, or **both.**

They may be said to consist of two parts: (1) **the frame,** (2) **the sash** or **sashes.**

The sashes, carrying the **glass,** are secured in various ways to the frame, which may be **solid** or **hollow.** In the latter case it is known as a **boxed** frame.

The following windows will be described in this chapter:—

(1) Solid framed with fixed sash.
(2) " " centre hung sash.
(3) " " vertically hung sashes.
(4) Box framed with sliding sashes.

134. Solid framed window with fixed sash.—The frame is similar to that used for doors, and consists of two vertical pieces or **posts**, a crosspiece or **head,** and a **sill,** the whole put together by means of mortise and tenon joints. The frame is rebated all round to receive the sash, which is generally put in from the outside, so as to be more weathertight, and not so liable to be blown in by the wind, which in this case only serves to make the joint between sash and frame closer. The sill will be described further on. The sash is mortised and tenoned at the corners, and when moulded or chamfered is mitred at the angles.

Fig. 246 shows a vertical section through a fixed sash or fanlight above an external door. The sash, in this case fixed in the door frame, consists of a top and bottom rail with two

vertical stiles. The lower rail is rebated into a horizontal piece termed a **transom,** which serves also as the **door head,** and is **weathered** to throw off the water. The glass may be secured in the frame with putty. If the sheet is large, a bead or moulding nailed, or, what is better, screwed to the sash, should, however, be used to keep it in position as shown in the figure.

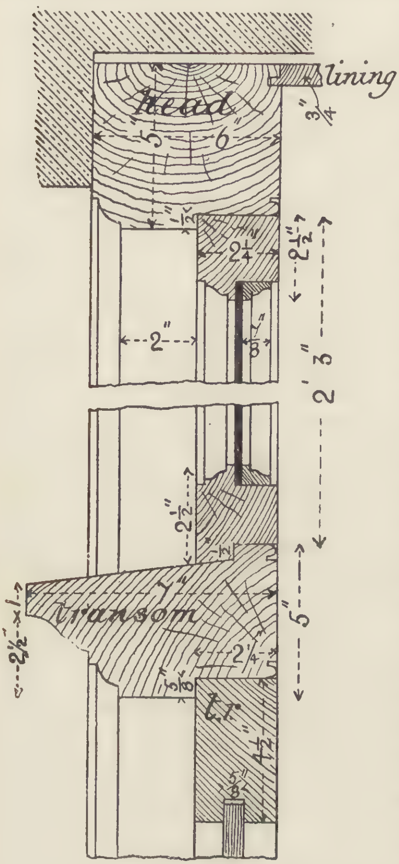


Fig. 246.

135. Solid framed window with centre hung sash.—An example of this construction is given in fig. 247. The frame in this instance has an oak sill, having its upper surface bevelled to throw off the water and rebated to fit the bottom rail of the sash, and its under side grooved. It rests on the stone window sill, which has a groove worked in it corresponding to that in the oak sill. Into this groove is inserted a hard wood or iron **water bar.** This intercepts any water which may find its way between the two sills from the outside.

The inside face of the frame is grooved to receive the plaster lining of the jambs and soffit. The opening is finished below with a **window board** grooved and tongued into the oak sill.

The method of rendering this window weatherproof at the sides and head should be noticed. A bead is nailed round the **upper half of the frame** and the **lower half of the sash** outside the window, while inside, the bead runs round the

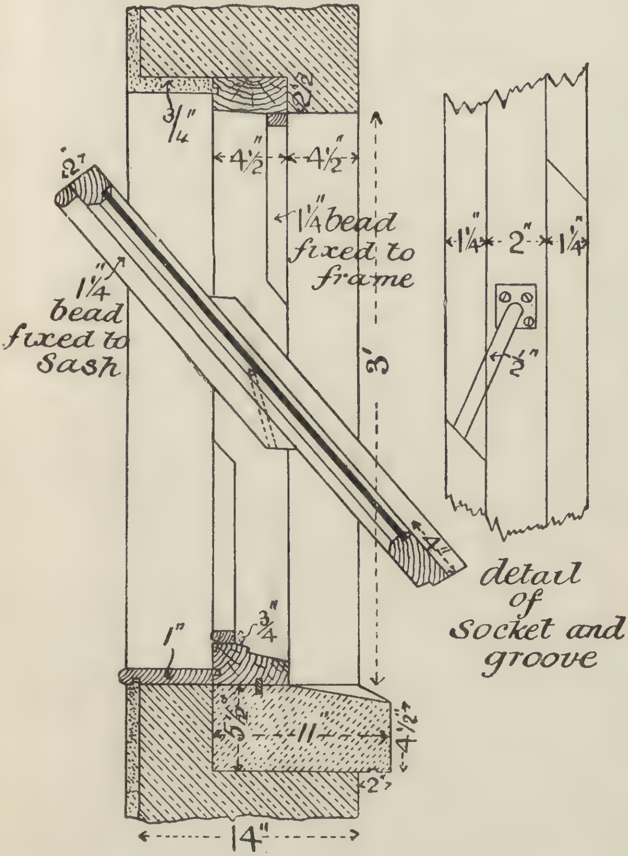


FIG. 247.

upper half of the sash and **lower half of the frame.** When the window is closed, these beads appear continuous.

Pivoted windows should always open so that the lower rail

swings **outwards**, as in the figure. If this is not attended to, the rain will, when the window is open, trickle down the inclined sash into the room.

In the example shown, the **pivots** on which the sash revolves are fixed to the frame and work in iron **sockets** screwed to the stiles.

The enlarged detail in fig. 247 shows this socket, and the groove leading to it along which the pivot passes when the sash is lowered into its position in the frame.

By keeping the pivots a little above the **centre of gravity** of the sash the latter may be made self-closing.

136. Solid framed window with vertically hung sashes.—Fig. 248 illustrates a little more than one half the elevation of a window of this description.

This is sometimes called a **casement** or **French window**. The sashes are hinged to the stiles and made in this case to open **inwards**. The frame is put together in the same way as that in the last example. Fig. 249 gives a vertical section through this window.

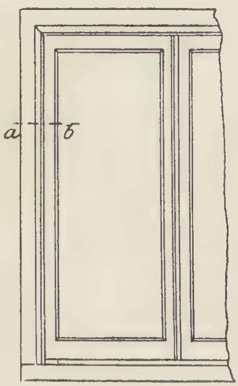


FIG. 248.

The only point calling for remark is the method here adopted of forming a watertight joint between the bottom rail of the sash and the sill.

A groove $\frac{1}{2}$ inch deep is cut along the upper surface of the latter. Into this groove is driven a wrought-iron strip one inch wide and $\frac{1}{4}$ inch thick.

The lower rail of the sash is rebated to fit closely against the projecting part of the slip when the window is closed, the overhanging portion of the rail being **throated** to break the flow of any water which may find its way underneath.

A horizontal section through the **meeting stiles** would be similar to that shown in fig. 255, or the rebates may be formed as in fig. 237.

Where possible, casements should open outwards. No difficulty is then experienced in keeping the joints weather-

proof. If formed so as to open inwards, it is almost impossible to keep out the wet in exposed situations.

Fig. 250 is a horizontal section (enlarged) on the line *a b*,

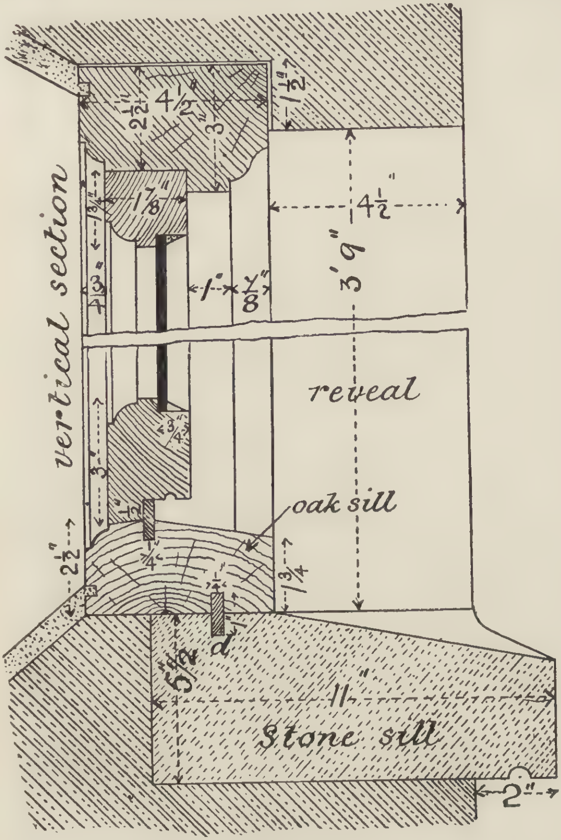


FIG. 249.

fig. 248. It shows an additional precaution which is often taken to exclude rain from the joint between the hanging stile and frame.

In addition to the rebate, a semicircular recess or throat is cut in the frame, into which fits a corresponding projection on the stile.

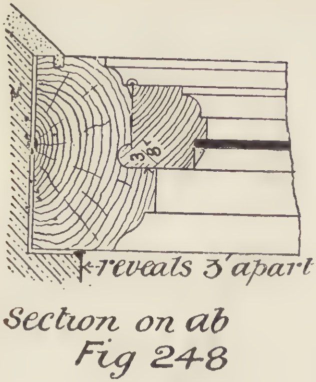


FIG. 250.

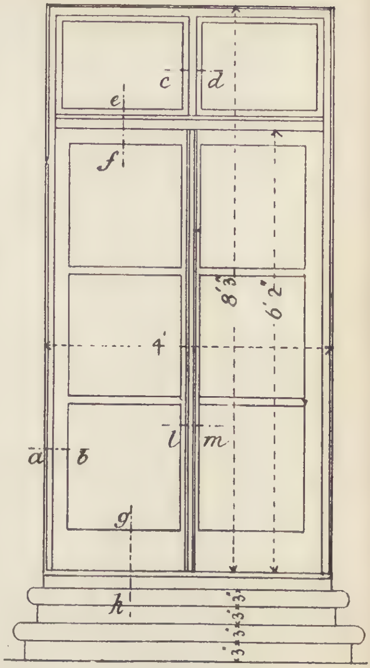


FIG. 251.

A casement or French window opening down to the floor and outwards is shown in elevation in fig. 251. Each sash is divided into three parts by horizontal sash bars framed into the stiles.

The upper portion of the window is fixed and separated from the folding sashes by a **transom.**

The vertical piece down the centre of the fixed light is termed a **mullion.**

Two **stone steps** are shown leading from the ground to the floor level.

Fig. 252 is a horizontal section through the frame and hanging stile. It shows the same construction as that given in fig. 250.

A horizontal section through the mullion is given

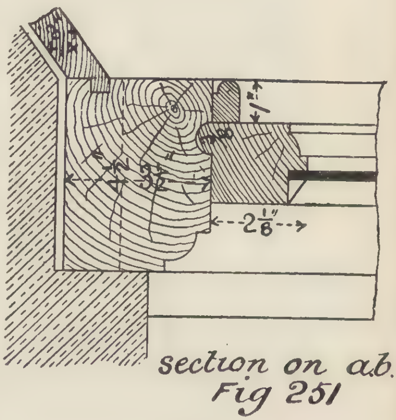
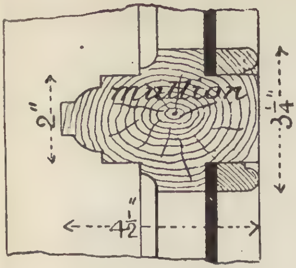
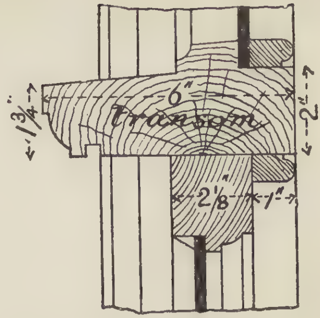


FIG. 252.



Section on cd
Fig 251

FIG. 253.

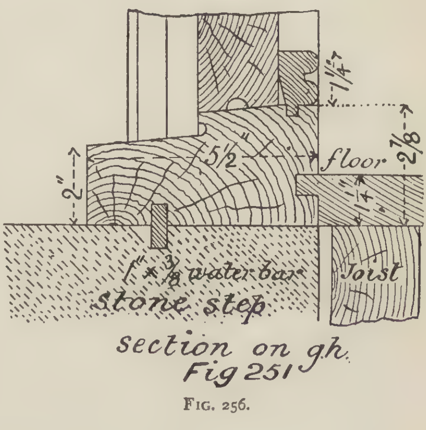


Section on ef.
Fig 251

FIG. 254.

Section on lm.
Fig 251

FIG. 255.



Section on gh.
Fig 251

FIG. 256.

in fig. 253. It will be seen from this and the next figure that the glass in the fixed light is not secured in a sash and then fixed into the framework, as in fig. 246, but the head, stiles, transom, and mullion are rebated on the inner side to receive the glass, which is retained in position by a bead nailed all round the in side of the rebate.

Fig. 254 shows a vertical section through the transom and top rail of the casement. The former is **weathered** on the upper surface and **throated** below for the purposes already explained.

With reference to this figure, it may be

remarked, that in order to save labour and make a stronger job, many architects and builders simply bevel off the upper surface of the transom from its highest point, instead of working it so as to be somewhat more in keeping with the design of the mullion.

Fig. 257.

Fig. 255 is a horizontal section through the meeting stiles. It illustrates a good method of keeping the wet from entering the window at this joint. A semicircular groove and projection are worked on each stile. These fit together in the manner

indicated. As a further protection, the joint is covered on the outside by a bead planted on one of the stiles.

A vertical cross section through the sill is given in fig. 256. This sill is of oak, grooved to receive a metal **water bar**. The floor boards are also shown grooved and tongued into the sill, the upper surface of which is bevelled to throw off the wet. To prevent water being blown along under the lower rail, a groove is cut between the two bevelled surfaces of the sill. The under side of the rail is also throated.

The bead against which the lower rail shuts is splayed back, as shown in the figure. By this means the sashes will not be prevented from shutting closely should a little dust or dirt accumulate at this point, as it is so apt to do.

In one or two of the preceding drawings in this chapter, panes of glass are shown fastened in position by means of **putty**. This method should never be used with large sheets. These ought to be fixed with beads, as in figs. 253 and 254.

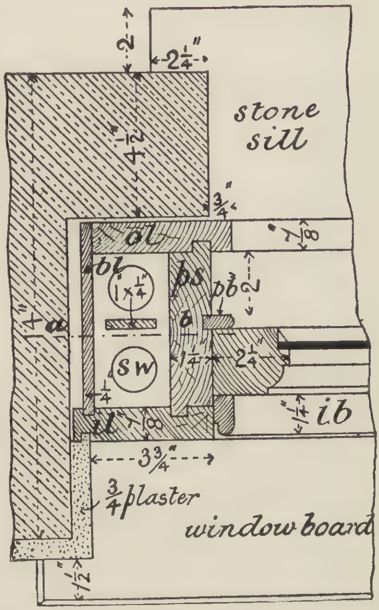


Fig. 258.

137. Box framed window with sliding sashes.—Fig. 257 shows an elevation, half inside and half outside, together with a vertical section, of a window of this description.

There are **two sliding sashes**, each divided by horizontal and vertical bars into four parts.

The remaining diagrams of this chapter are lettered to indicate the various parts, thus :—

i l	. . . .	inside lining.
o l	. . . .	outside lining.
b l	. . . .	back lining.
i b	. . . .	inside bead.
p b	. . . .	parting bead.
p s	. . . .	pulley stile.
s w	. . . .	sash weight.
h	. . . .	head.

138. The boxed frame.—Fig. 258 gives a horizontal section through a boxed window frame. It consists of the **inside lining, outside lining, pulley stile,** and **back lining,** which are put together in the way indicated.

In common work no grooves and tongues are used, the pulley stile being simply cut square and the linings nailed to it. The back lining is shown grooved into the inside and nailed to the outside lining.

A **groove** is run down the centre of the pulley stile, into which a narrow slip of wood termed a **parting bead** is driven. This serves to keep the sashes apart.

There are two cast-iron **sash weights** on each side of the window, kept apart by means of a thin **parting slip**, generally of **wood,** sometimes of **sheet zinc.** For heavy work square lead weights are frequently used.

The weights are hung by cords over brass or iron **pulleys** fixed near the top of the **pulley stile.**

In fig. 258 the inside lining is grooved all round to receive the plaster lining of the jambs and soffit.

To keep the lower sash in position a bead is nailed all round the inside edge of the frame.

The outside lining projects within the frame and serves a purpose similar to that of the inside bead. In this example the latter is $\frac{3}{8}$-inch deeper than the thickness of the inner lining, so as to cover the joint between it and the pulley stile.

A vertical section on *a b*, fig. 258, is given in fig. 259, to show the method of fixing the pulley stile into the head and sill of the frame. The stile is usually grooved and tongued to the window head. In this example the tongue is half

dovetail in section. The lower end of the pulley stile is housed and wedged into the sill.

The parting slip is hung from the head by means of a small nail (see figs. 259 and 261).

The sash weights are introduced into the box frame through a hole or **pocket** cut in the pulley stile, which is afterwards closed with a **pocket piece**.

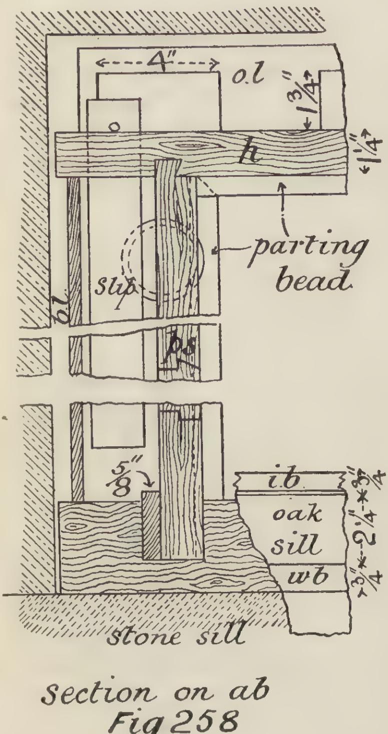


FIG. 259.

This pocket piece is rebated at both ends, the upper being bevelled in addition in order to keep the piece in its place (see fig. 260). The pocket is usually cut in that portion of the pulley

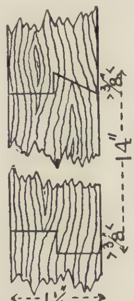


FIG. 260.

stile against which the lower sash works, and extends in width to the centre of the groove for the parting bead. When the latter is in position, the pocket piece cannot therefore be removed.

The section given in fig. 261 shows the head grooved and tongued into the linings, wooden blocks being glued into the angles to stiffen the frame. Instead of plaster, a wood jamb and soffit lining is shown. Reference to the figure will explain the method of fixing it.

In common work it is unusual to find the parting bead carried across the top of the window as illustrated.

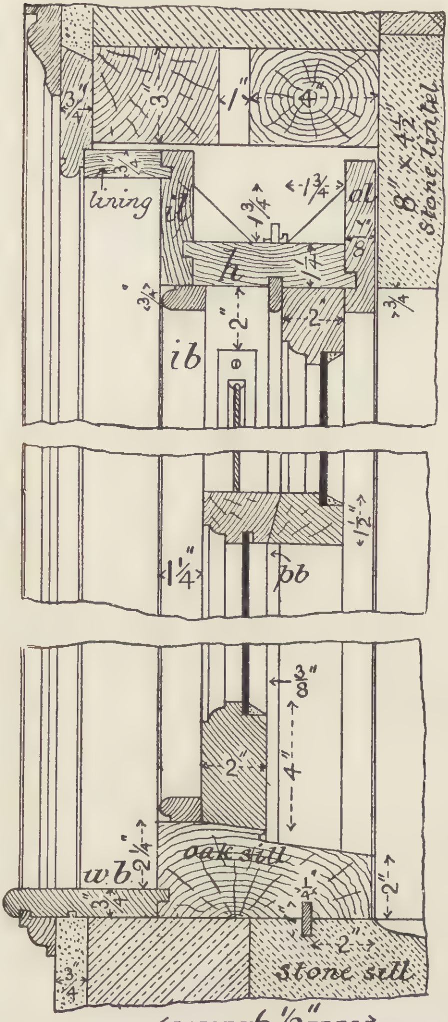


Fig. 261.

139. The **sashes.**—The upper sash slides in the frame between the **outside lining** and **parting bead,** the lower sash between the **parting bead** and **inside lining.**

When the window is closed the bottom rail of the top sash and the top rail of the bottom sash come together, and are termed **meeting rails.** They are bevelled off, as shown in fig. 261, so as to fit closely. In better class work the meeting rails are frequently finished as

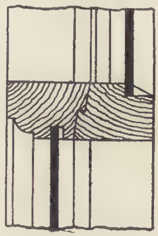


Fig. 261 *a*.

in fig. 261 *a*. It makes a better fit, and prevents the possibility of burglars tampering with the fastener by inserting a knife between the rails.

The top sash is rebated outside to receive the glass. On the underside of the meeting rail of the lower sash, a groove is substituted for the rebate, in order to keep the lower surfaces of the meeting-rails in one plane.

The bottom rail of the inner sash is deeper than the others, and in fig. 261 is simply bevelled off at the bottom to fit the sill. Fig. 262 shows a better way of preparing it. The rail is checked out to fit the step in the sill, the lower surface being throated to intercept any wet.

FIG. 262.

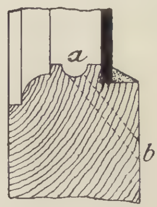


FIG. 262 *a*.

Reference may here be made to a method, frequently adopted, of getting rid of the water which condenses on the inside of the window panes and trickles down, collecting on the upper edge of the lower rail. A groove is worked along this edge, communicating with the outside of the window by means of two or three holes bored obliquely through the rail, as shown in fig. 262 *a*. These holes are, however, frequently left blocked up by paint and dirt, and are then useless.

The sashes are hung by cords which pass over pulleys as before mentioned, one end being fastened to the cast-iron weight, and the other nailed in a groove cut in the style to receive it.

The weights for the upper sash should be together a little heavier than the sash. The lower sash should be slightly heavier than its weights. By this means the sashes have always a tendency to remain closed.

140. Sash bars.—When a fixed sash has horizontal and vertical bars, the latter should be continuous, and tenoned into the top and bottom rails. The former must then be divided and tenoned into the stiles and vertical bars.

Two methods of doing this are given in fig. 263. In the first case, a mortise is cut through the vertical bar the whole width of the square part, *a b*. The ends of the horizontal bars H B are tenoned to fit the mortise, the moulded portion being scribed to fit the vertical bar. The right-hand side of the figure shows the bar in position.

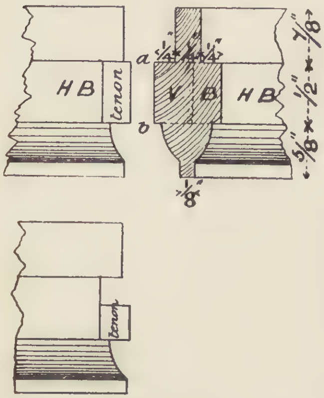


Fig. 263.

In the lower figure a part of the tenon is **haunched** out: this does not require so large a mortise in the other bar, and is known as **franking.** When great strength is required, a **dowel** may be used in addition to the tenon.

As a rule, those sash bars which have to bear the greater strain should be continuous. In sliding sashes these will be the vertical, and in casements the horizontal bars.

Box-framed windows are frequently inserted in thin walls, with only a $4\frac{1}{2}$ inch recess for the frame. In this case the inside lining stands its own thickness or thereabouts beyond the face of the brickwork, the outer edges being bevelled so as to form a key for the plaster, which is laid on the wall flush with the face of the lining. The joint between plaster and lining is afterwards concealed by an architrave.

Exercises on Chapter XI.

1. Vertical section of a fanlight over an outer door, fig. 246. Draw to a scale of $\frac{1}{6}$ and show to the same scale an inside and outside elevation, the door posts being 3′ 6″ apart in the clear.

2. Draw fig. 247 to a scale of $\frac{1}{4}$.

3. Draw the section given in fig. 249 to a scale of $\frac{1}{4}$, and add inside and outside elevations. The width of the window opening between the reveals is 3′.

4. Give a horizontal section of the window mentioned in the last exercise. Scale 3″ to one foot.

5. Outside elevation of a French window, fig. 251. Show to a scale of $\frac{1}{4}$ sections on the lines *a b*, *c d*, *e f*, *g h*, *l m*.

6. Draw a complete inside elevation of the window shown in fig. 251. Scale $\frac{1}{12}$.

7. Draw figs. 258 and 259 to a scale of $\frac{1}{2}$.

8. Vertical section through a double-hung sash window, showing details of the sill, meeting rails, and head. Draw to a scale of $\frac{1}{2}$.

9. Draw full size the plan of the intersection of vertical and horizontal sash bars shown in fig. 262; give also front and back elevations of the same.

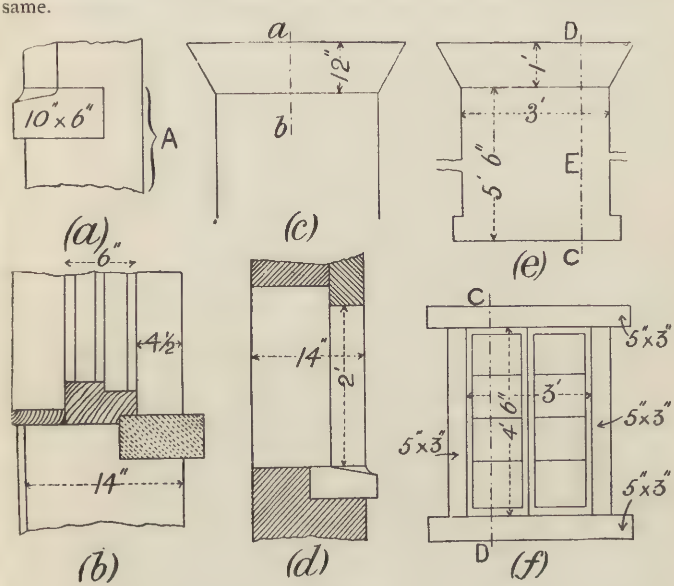


Fig. 264.

10. Cross section of a stone window sill in a 14″ brick wall, fig. 264 (*a*). Draw to a scale of 1½″ to 1′, showing it throated and grooved for a metal weather tongue. Show the joints of the bricks at A.

11. A vertical cross section through an ordinary window sill, fig. 264 (*b*). Draw to a scale of 1″ to 1′, making any additions you may consider necessary to make a good weather-tight joint.

12. Elevation of a window head in an 18″ brick wall, fig. 264 (*c*). Draw a section through *a b* to a scale of 1½ inch to a foot, showing all the details connected with the head of the frame and the top sash, with a plastered soffit and the wall battened and plastered.

13. Section of a window opening in a 14″ brick wall, fig. 264 (*d*). Draw to a scale of 2″ to a foot, showing all details of a $1\frac{1}{2}''$ sash hung on pivots to a solid frame, the sash to be shown half open.

14. Elevation of a window opening with $4\frac{1}{2}''$ brick reveals in a wall $1\frac{1}{2}$ brick thick, fig. 264 (*e*). Draw to a scale of 1″ to a foot and add window sill and solid window frame in elevation, and give section through C E D showing sill, frame, and window head.

15. Draw in elevation to a scale of 1″ to a foot, $1\frac{1}{2}''$ sashes for the above, giving an enlarged section on E D to a scale of $\frac{1}{4}$ full size of the sash frame and sash, the frame having a bead on it and the sashes being moulded.

16. Outside elevation of $1\frac{1}{2}''$ casement, bevelled bar sash, and solid frame, fig. 264 (*f*). Give a section on C D. Scale 1″ to 1′.

17. Give a horizontal section through one side of a sash frame for a double-hung sash, and a vertical section through the head of the same, the sash frame to be for an opening $5' \ 6'' \times 3'$ in the clear. Scale $\frac{1}{4}$ full zize.

18. Give a vertical section to a scale of $\frac{1}{6}$ through the sill of a double-hung window sash, showing a stone sill $10'' \times 6''$ resting on a 14″ brick wall, an oak sill $6'' \times 3''$, a $1\frac{1}{2}''$ window board, and a bottom rail of a 2″ sash ; also give a cross section through the meeting rails.

19. Give vertical sections, half full size—1st, through the bottom sash rail and oak sill of a $1\frac{1}{2}''$ double hung window ; 2nd, through the meeting rails.

20. Give a horizontal section $\frac{1}{6}$ full size through a French casement window in a 14″ brick wall, the opening to be 4′ wide ; frame flush with inside of room and hung with $2\frac{1}{4}''$ folding sashes opening inwards, the joint between the frame and the plaster to be covered with an architrave moulding.

21. Draw a horizontal section half full size through one side of a window frame for double-hung $1\frac{1}{2}''$ moulded sashes, taking $\frac{5}{8}''$ inside and outside linings, $\frac{1}{4}''$ pulley piece, $\frac{3}{8}''$ back lining, $\frac{3}{8}''$ parting bead, $1'' \times \frac{5}{8}''$ inside bead, $\frac{1}{4}''$ parting slip, sash stile to be shown in the section.

22. Give a vertical section $\frac{1}{4}$ full size through both the wood and stone sills of a window opening for a $1\frac{1}{2}''$ swing sash, the stone sill to be $6'' \times 4''$, weathered and throated, and to rest on a 9″ brick wall, the wood sill to be $4'' \times 3''$, with a $1\frac{1}{4}''$ inside bead and a $1\frac{1}{4}''$ window board.

23. Draw to a scale $\frac{1}{2}$ full size a horizontal section through one side of a window frame for 2″ double-hung sashes, taking the following dimensions : $\frac{3}{4}''$ inside and outside linings, $1\frac{1}{4}''$ pulley piece, $\frac{1}{2}''$ back lining, $\frac{3}{8}''$ parting bead, $1\frac{1}{2}'' \times \frac{3}{4}''$ inside bead, $\frac{1}{4}''$ parting slip.

24. Give a cross section $\frac{1}{4}$ full size through an ordinary window sill, showing an oak sill $6\frac{1}{2}'' \times 3''$ for hung sashes, tongued to a stone sill $10'' \times 6''$, sunk, weathered, and throated, and built into a 14″ brick wall, which is to be rendered on inside and finished with a $1\frac{1}{4}''$ window board tongued to oak sill.

CHAPTER XII.

NOTES ON ROLLED IRON JOISTS, CAST-IRON GIRDERS, CANTILEVERS, ETC.

THE manufacture of wrought iron, and of machinery for rolling it into various useful shapes, has been brought to such perfec-

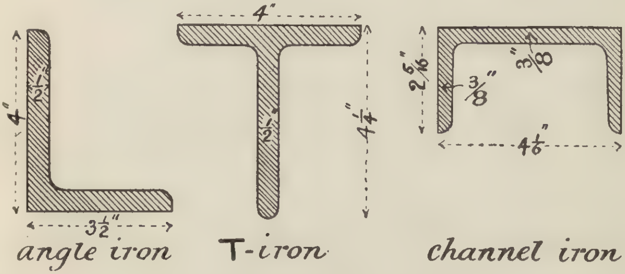


FIG. 265.

tion of late years that it has to a very large extent replaced cast iron as a material for forming **girders, bressummers,** etc.

Some of the market forms of wrought iron are given below. **Angle iron** and **T-iron** are largely used in iron roof construction.

Rolled iron joists, or **girders,** have already been mentioned in Chapter V., in which their use as floor supports is illustrated.

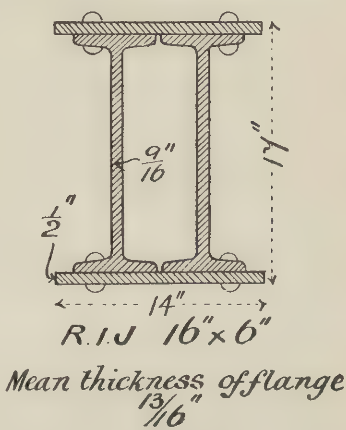


FIG. 266.

Where the weight to be borne is excessive, two or more rolled iron joists may be united by wrought-iron plates, as in fig. 266. A compound girder of the dimensions given, with a span of 12 feet, is capable of sustaining a distributed load of about 100 tons.

Girders of this description, when required of sizes which preclude the use of rolled iron joists, are built up of plates and

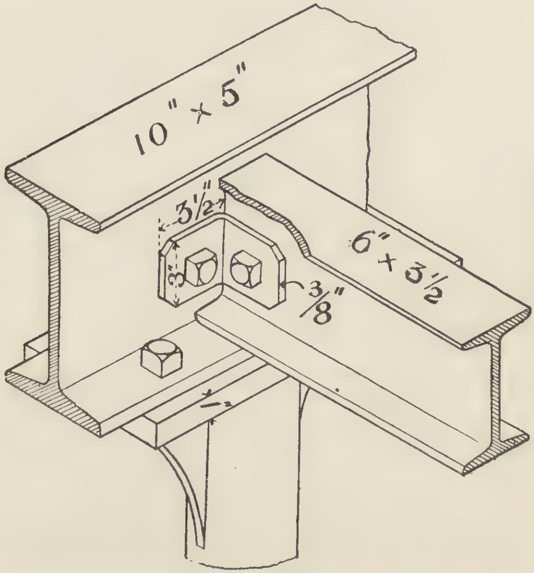
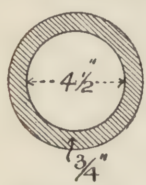


FIG. 267.

angle iron firmly riveted together. These are known as **plate** or **box girders,** according to the method of construction, and will be considered in another volume.



Section of hollow cast iron column

FIG. 268.

Fig. 267 is an isometric projection of the junction between what may be termed one of the **main girders** and **binders** of a fire-proof floor.

The construction of the floor itself we shall not touch on.

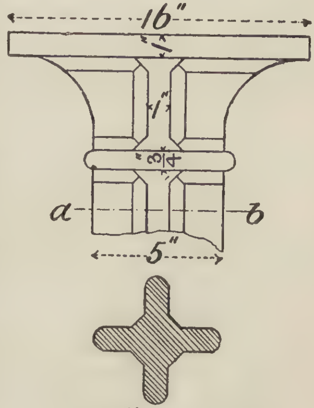
The main girder is supported by a **hollow cast-iron column,** a section of which is given in the next figure, and is secured to it by four bolts, $\frac{5}{8}$ inch in diameter, which pass through the lower flange and cap of the column. The smaller joist or

binder rests on the lower flange of the main girder, to which it must be carefully fitted in order to have a good bearing.

These are held together by wrought-iron **lugs** bolted through the webs.

In the place of columns, **cast-iron stanchions** are frequently used as supports.

Fig. 269 gives a horizontal section and elevation of the head of a stanchion suitable for carrying the girder in fig. 267.



Section on ab

Fig. 269.

In connection with the above remarks on the use of iron girders for floors the following extract from the 'American Architect' may be of interest :—

'Not long ago a great fire took place in Berlin, totally destroying a structure composed wholly of brick and iron, and built with the solidity characteristic of German work. The building was a storehouse, and was about 100 feet wide and 150 feet long, six storeys high, with a small courtyard in the centre. A heavy brick wall divided it through the middle, and the floors were all made with brick arches turned between iron beams, which rested on the walls and on ranges of iron girders supported by cast-iron columns. The doors and the partition wall were of plate iron.

'Five months after the building was substantially completed, one or two temporary openings were made in the third storey floor for the purpose of finishing some part of the work, and while these were still open an accident occurred by which fire was set to some goods stored in the third storey. The flaming brands immediately fell through the holes in the floor, setting fire to the goods in the next storey below, which were mostly cotton and woollen materials, and although the fire engines arrived in five minutes after the fire started they were too late to be of any service.

'Five minutes seem a short time for a fire starting in a little bundle of dry goods to accomplish the destruction of a huge building in the construction of which there was not a trace of inflammable material. But no sooner had the nearest bales become kindled than the iron beams over them, quickly heated by the flames, expanded violently, wrenching the girders and in many cases breaking off the capitals of the columns. In this effort the beams themselves were bent and twisted, letting the brick floor arches fall, and so quickly did this effect occur that many of the floor arches had fallen out before the engines arrived.

'The eastern half was cut off by means of the iron doors, all of which had been duly closed; but these soon became red-hot from the action of the fire behind them, and in that way set fire to goods lying against them, and they also warped enough to let the flames through and hasten the effect; so that in one hour from the first alarm little remained of the western half of the building but the tottering outside walls, while the three upper storeys of the eastern half, notwithstanding the brick partition wall and the iron doors, were totally destroyed, and the lower storeys nearly ruined by the fall of the upper door arches.

'On examining the place after the fire it was found that out of 100 columns which originally held the floors, 38 had been thrown completely out of their places, while 34 more, although they remained standing, were so broken or bent as to be useless, the only ones still fit for service being those in the lower storeys of the eastern half of the building.

'The girders were formed of iron beams or joists 18 inches deep, and these were in some places twisted like corkscrews by the strain which they had undergone.

'An expert commission was immediately appointed to study into the causes of the fire, and made a report expressing the opinion that no building could henceforth be considered fireproof unless the **flanges of iron beams** and **all portions of iron columns were covered by some non-conducting material.**'

141. Cast-iron girders and cantilevers.—The student

in the Elementary Course is required, in the words of the syllabus, 'to be acquainted with the proper cross section of cast-iron beams for use in floor girders or bressummers, or as cantilevers, and should be able to draw such a section in its right proportions from given dimensions of flanges.'

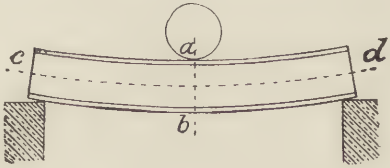


FIG. 270.

Before dealing with this part of the subject it will be as well to consider the condition of a beam supported at both ends, and carrying a load either **distributed** or **concentrated** on its upper surface.

The effect of the load is to cause a **bending strain** in the beam. The fibres of the material at the top are therefore in **compression**, while those at the bottom are in **tension.**

Hence it is manifest that in passing from the compressed part *a* to the extended part *b* a portion of the beam will be found, say, along the line *c d*, in which the fibres of the material are not subjected to either of these strains.

This line *c d* is therefore termed the **neutral axis.**

It will be easily understood that the material along the neutral axis of a beam contributes very little towards its strength. It may therefore be removed and placed where it adds to the efficiency of the beam as a weight supporter.

Thus it is that we have rolled iron joists of the form already described and illustrated.

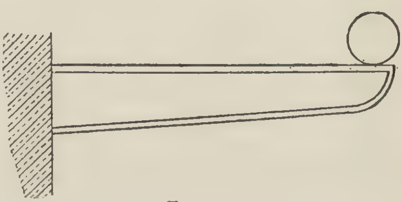


FIG. 271.

A beam having one end only supported, as in fig. 271, is termed a **cantilever.** Under the action of weight the upper

part will in this case be extended, the lower portion being in compression.

The facts just alluded to must be taken into consideration in designing a cast-iron beam. It will be seen on reference to Chapter XIV. that the resistance of cast iron to compression is something like six times as great as it is to tension. Hence that flange of a cast-iron girder which is in tension requires about six times the amount of material that is used in the flange subject to compression.

In practice, however, the sectional areas of the flanges of a cast-iron girder are made as 3 to 1 or 4 to 1.

Take the case of the cantilever in fig. 271. The upper flange is in tension, the lower in compression. The proper section, therefore, would be that shown in fig. 272, the sectional area of the upper flange being 24 square inches, while that of the lower is only 6 square inches. Thus, knowing the size of one flange it is an easy matter to calculate the dimensions of the other.

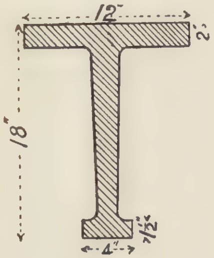


FIG. 272.

With regard to the depth of the beam, experience fixes it at about $\frac{1}{10}$ to $\frac{1}{12}$ the span.

If the girder is supported at both ends the larger flange should be undermost.

The web should be tapering in section, its thickness at the top being equal to that of the upper flange and at the bottom to that of the lower flange. The internal angles are rounded off, as shown in the figure.

The flanges of wrought-iron girders are made both the same size, since the resistances of this material to tension and compression are about the same.

The term **bressummer** is applied to a girder spanning a wide opening and usually supporting brickwork.

The strength of a girder depends not only on the disposition of the material as just described, but also on the method of support and the manner in which the load is applied.

Without attempting any explanation, which must be reserved

for a future volume, it will be sufficient to draw the student's attention to fig. 273, which shows the **relative** weights capable of being sustained by the same girder under different conditions.

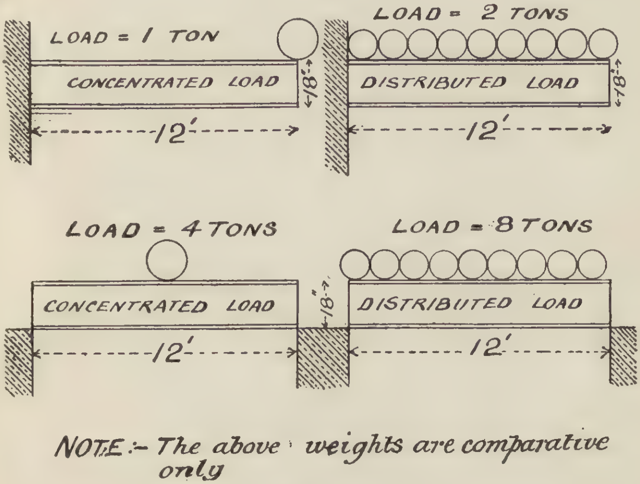


FIG. 273.

If the girder has its ends firmly fixed instead of merely resting on supports, it would (comparatively) sustain a load of 8 tons concentrated at its middle point.

EXERCISES ON CHAPTER XII.

1. Section of a cast-iron beam to be used as a girder in a fireproof floor, fig. 274 (*a*). Should the flange marked X or that marked Y be uppermost? and which is in tension, which in compression? Supposing the same beam to be built into a wall at one end and to be loaded on the projecting part, which flange should be uppermost?

2. Section of a cast-iron girder carrying a floor above, fig. 274 (*b*). Draw to thrice the scale, making any correction you may deem necessary.

3. Elevation of a cast-iron girder resting on two supports, fig. 274 (*c*). Give a cross section of the girder $\frac{1}{4}$ full size, one flange to be $1\frac{3}{4}'' \times 10''$ and the other $1\frac{1}{4}'' \times 3\frac{1}{2}''$, and the mean thickness of the web $1\frac{1}{2}''$.

4. Single line section of a cast-iron girder which is to be supported at both ends and loaded at the centre, fig. 274 (*d*). Draw to a scale of 2′ to an inch, making the top flange 1″ thick, the bottom flange $1\frac{1}{2}''$, and the web averaging $1\frac{1}{4}''$.

5. Section of an iron girder, fig. 274 (*e*). Draw half full size, stating against it whether it is intended for a cast- or a wrought-iron girder. Without altering the dimensions make any improvement in the form you may deem advisable.

6. Plan showing the rolled iron cross girders of a floor running into the main girders over the head of a cast-iron column, fig. 274 (*f*). Draw to scale of 2″ to a foot a section through A B, showing in elevation the head of a column, the mode of attaching the cross girders to the main girders, and the main girders bolted to the columns.

7. Give a cross section, $\frac{1}{3}$ full size, of a rolled iron joist 9″ deep, with $4\frac{1}{2}'' \times \frac{5}{8}''$ flanges and $\frac{1}{2}''$ web.

8. Give a vertical cross section, to a scale of $\frac{1}{6}$, through a cast-iron

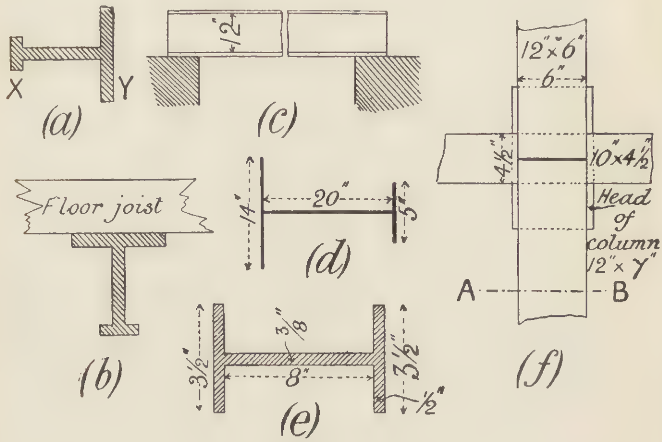


Fig. 274.

cantilever 9″ deep, the flanges being respectively $4'' \times 1''$ and $2\frac{1}{2}'' \times \frac{5}{8}''$, the web varying from 1″ to $\frac{5}{8}''$.

9. Give a full-size section of a rolled iron joist 5″ deep, flanges $3'' \times \frac{1}{2}''$ and $\frac{3}{8}''$ web.

10. One of the flanges of a cast-iron cantilever is $5'' \times 1\frac{1}{2}''$, and the other $2'' \times 1''$; its web is 9″ deep and varying from 1″ to $1\frac{1}{2}''$ in thickness. Give a vertical cross section $\frac{1}{4}$ full size.

11. Give a cross section, half full size, of a rolled iron floor joist $4\frac{1}{2}'' \times 9''$, with a $\frac{3}{8}''$ web and $\frac{3}{4}''$ flanges.

12. The top flange of a cast-iron girder is $4'' \times 1''$, the bottom flange $12'' \times 1\frac{1}{2}''$, and the depth of the girder is 16″. Draw the cross section to a scale of 2″ to one foot.

CHAPTER XIII.

IRON ROOFS.

142. General remarks.—Reference has already been made in Chapter VII. to the use of **iron king rods, ties,** and **struts** in roofs mainly composed of **wood.** In the present chapter a few notes will be given, dealing with the form and construction of iron roof trusses for spans up to 40 feet.

The material most largely used is **wrought iron.** As before mentioned, its manufacture has been so improved of late years that it may be obtained of all sections and weights.

The various members of a roof truss may be said to be either in **tension** or **compression,** the former being indicated in the diagrams by **thin,** the latter by **thick** lines.

Since cast iron offers a much larger resistance to compression than to tension, it is therefore frequently used for struts, etc. But the ease with which wrought iron can be worked, and its adaptability to all situations and purposes, are causing it to entirely supplant the former material in roof construction.

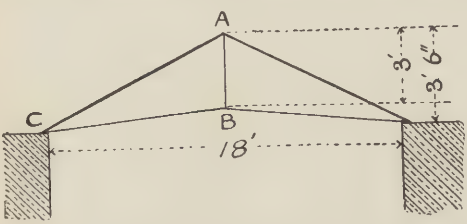


FIG. 275.

Roofs are now often constructed without the aid of a single particle of cast metal. In some cases, however, the **shoes** and **heads** receiving the ends of the rafters are made of this material.

The various parts are bolted or riveted together. Rivets are made of wrought iron or mild steel, and for this work are generally of the form known as **snap rivets,** the heads being nearly hemispherical.

The holes to receive them may be either **punched** or **drilled,** the latter being the preferable method.

In roofs of very large span allowance must be made for the **expansion** and **contraction** of the iron under varying temperatures. This is usually done by fixing one end only of the truss to its support, the other being free to move outwards or inwards, as the case may be. To facilitate this, the shoe or chair is made to rest on **rollers**.

The following trusses will be described and illustrated in detail :—

(1) King-rod roof truss without struts.
(2) King-rod roof truss with struts.
(3) Queen-rod roof truss.
(4) Trussed rafter roof with one strut.
(5) Trussed rafter roof with three struts.

143. King rod roof truss without struts.—An outline diagram of this simple form of truss is given in fig. 275. The rafters are of T-iron, while the king and tie rods are of round bar iron.

The rise of the roof varies with circumstances. In ordinary cases it may be taken at about $\frac{1}{5}$ of the span, while that of the tie rod may be about $\frac{1}{20}$ to $\frac{1}{40}$ of the span.

The rafters being unsupported at intermediate points, this construction is not adapted for spans of more than 20 feet.

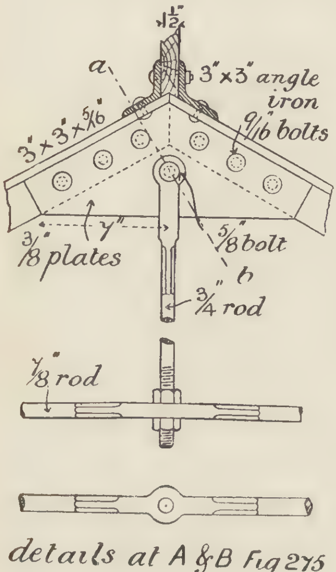


FIG. 276.

Fig. 276 gives details at the head and foot of the king rod. The T-iron rafters are bevelled off so as to butt one against the other at the apex of the roof. Two wrought-iron plates are then bolted securely to them, one on each side.

The upper end of the king rod is forked, and is suspended from the plate by means of a $\frac{5}{8}$-inch bolt. In some cases the end is forged out flat, so as to pass **between** the plates.

The lower end of the king rod has a screw thread cut on it. The tie rod is bulged or widened out and drilled to admit the vertical rod, which is then secured by two nuts. By this means the king rod may be shortened. This has the effect of raising the tie rod at the centre and drawing in the feet of the rafters.

A ridge board $1\frac{1}{2}$ inch thick is shown, kept in position by two angle irons bolted to the **tables** of the rafters. In many cases a specially designed cast-iron bracket, bolted to the rafters in the same way as the angle irons just alluded to, is used for this purpose, provision being made, in the form of a groove, for carrying the ridge-board.

Note.—It may here be mentioned that in giving the dimensions of T-iron in this chapter the plan has been adopted of **first** stating the width across the flat part, or **table** as it is called.

Fig. 277 shows the joint at the foot of the rafter. A wrought-iron shoe receives the stem of the T-iron, which is secured to it by means of bolts, one of which passes through the eye of the tie rod. This latter is forked so as to embrace the chair.

The bed plate is fastened to the stone template by **rag bolts** fitting into holes of dovetail section and run with lead.

The front edge of the plate is also turned down about 2 inches, and thus assists in withstanding the thrust of the rafter.

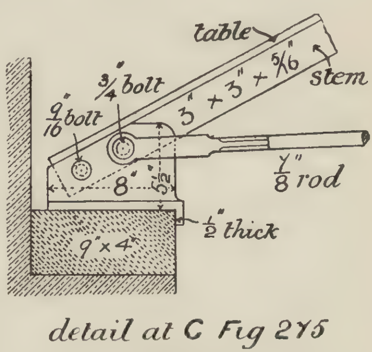


FIG. 277.

144. King rod roof with struts.—Fig. 278 illustrates an iron roof truss resembling in the disposition of its members the wooden king post truss illustrated in Chapter VII.

In this example the rafters are of T-iron, the struts of angle iron, and the king and tie rod of round rod iron.

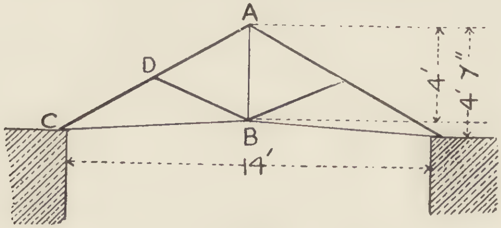


Fig. 278.

The joints at A and C resemble those in the preceding example, and therefore need no explanation. A modification

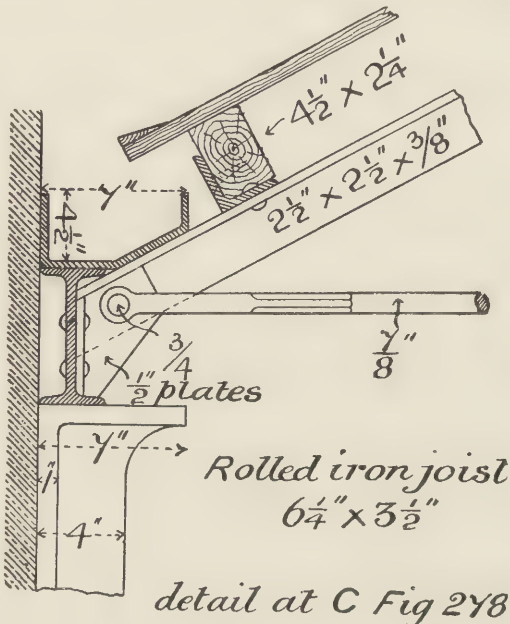


Fig. 279.

of the latter, however, is given in fig. 279, which shows the method of supporting one end of the truss when from one cause or another it cannot be carried by the wall.

A cast-iron stanchion of T-section supports a rolled-iron joist, which runs along the whole length of the roof. To the web a couple of $\frac{1}{2}$-inch wrought-iron plates cut to the shape indicated are bolted or riveted. The stem of the T-iron rafter is received between these plates, and the end butts on the web of the joist.

The end of the tie rod is forked and bolted through the plates and rafter. A cast-iron **trough gutter** rests partly on the rolled-iron joist and partly on the truss.

This illustration shows one method of fixing the roof covering. At intervals up the roof slope, **angle iron purlins** are riveted to the principals, parallel to the ridge.

These are filled in with wood, to which the roof boarding can be fixed.

In Chapter VII. we restricted the term **purlin** to the horizontal timbers notched across the trusses, and supporting rafters of smaller scantling, which in their turn carry the roof covering.

The use of common rafters, however, is not frequent in iron roofs.

The wood filling may be secured to the angle-iron purlin by common screws, bolts, or coach-screws.

Sometimes small angle-iron laths are used, to which the slates are hung by means of zinc strips without the intervention of roof boarding.

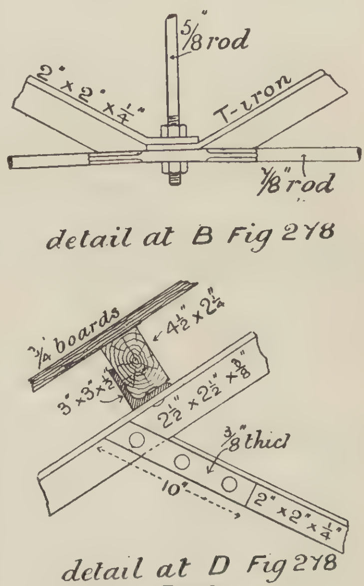


FIG. 280.

Fig. 280 shows the junction of strut and rafter, which in this example are both of T-iron. The former is bevelled off to fit against the latter, and the two are connected by wrought-iron plates bolted on each side.

In the same figure is shown the joint at the foot of the king rod. For about $3\frac{1}{2}$ inches from the foot of each strut the stem of the T-iron is cut away. The tables are then bent up and overlapped. A hole drilled through these and the tie rod,

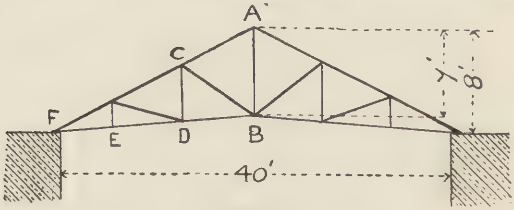


FIG. 281.

which is bulged out for this purpose, admits the king rod. The four members are then secured together by means of nuts, which also serve to tighten up the truss.

145. Queen rod roof.—A skeleton diagram of this form

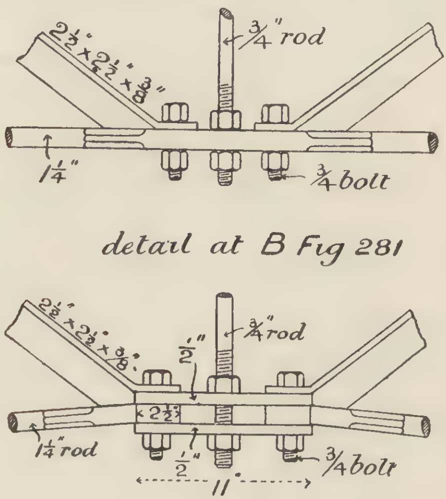


FIG. 282.

of truss is shown in fig. 281. The principal rafters and struts are of T-iron and the rods of circular bar iron.

The rafters are supported at two intermediate points, each

rafter being thus divided into three equal portions. The feet of the main struts are secured at the centre of the tie rod either as described in the last example or by the method shown in fig. 282 (upper diagram).

Here the ends of the struts are prepared as before, but instead of overlapping are bolted separately to the tie rod.

Sometimes in roofs of this description, with large spans, the tie rod is made in two parts. The ends are then forged out and drilled so as to form **eyes**, through which pass the bolts securing together the feet of the struts, the coverplates, and tie rod. An example of this construction is shown in fig. 282 (lower diagram).

Fig. 283 illustrates the connections at the head and foot of one of the queen rods, fig. 281.

The former joint has been already partly dealt with.

The only additional feature is the fork at the upper end of the queen rod, carried by a bolt through the cover plates and stem of the rafter.

The lower joint calls for little remark beyond the fact that, owing to the inclined surface, wrought-iron **washers** must be interposed in order to provide a bearing for the nuts.

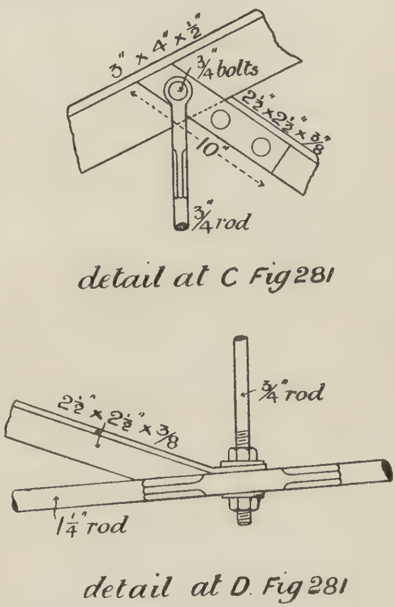


FIG. 283.

The joint at E, fig. 281, may be made by widening out the tie rod and drilling a hole to allow the king rod to pass through and then securing it with a couple of nuts.

In order to avoid interfering with the tie rod a clip is fre

quently formed at the end of the queen rod. This embraces the former instead of passing through it.

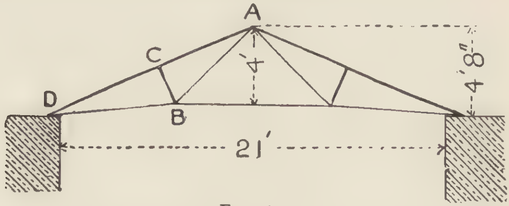


FIG. 284.

146. Trussed rafter roof.—A roof truss of this description with one strut is shown in outline in fig. 284. In this truss the rafters are of T-iron, the struts double flat bars kept apart by cast-iron distance pieces, and the tension rods of round rod iron.

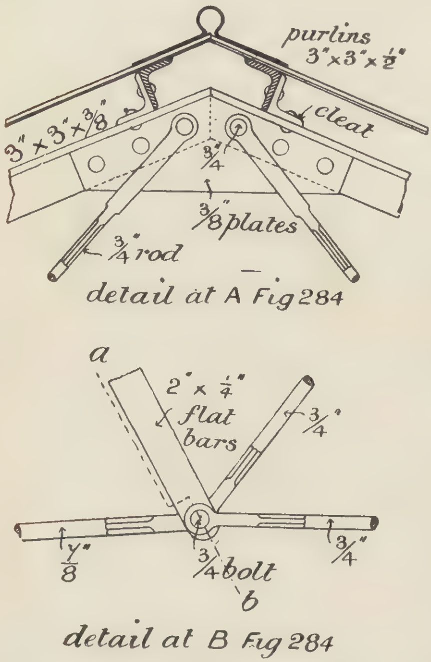


FIG. 285.

The joint at A is illustrated in fig. 285. The ends of the tension rods are forked, and are shown bolted through the stems of the T-iron rafters. This is not always the case. In fig. 288 the tension rods are bolted at the head through the cover plates only.

The roof covering in this instance is galvanised corrugated sheet iron carried on, and fixed to, angle-iron purlins, which are secured to **cleats** riveted on the back of the principal rafters. A zinc ridge

covering and roll is shown protecting the joints between the sheets at the apex of the roof. It need hardly be added that the sheets are laid with the corrugations running up and down the slope of the roof. They should overlap about 6 inches, and the purlins should be about 6 feet apart.

Mention has already been made that the struts are composed of flat bar iron 2 inches wide and $\frac{1}{4}$ inch thick. Each strut consists of two of these bars. The upper ends are bolted through the rafter.

The joint at the foot of the strut is shown in figs. 285 and 286. From these it will be seen that the flat bars of the strut are bolted one on either side of the flat eye of the tension rods. Outside the bars comes the fork of the tie rod.

A section on *a b*, fig. 285, is given in the next illustration, and will render the construction clear. Cast-iron distance pieces (shown in section) secured with $\frac{1}{2}$-inch rivets are inserted at intervals so as to give the strut a tapering form.

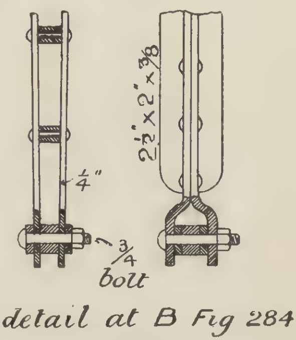


FIG. 286.

Frequently the strut is made of two T-irons riveted with their tables together as shown. In this case the joint at the foot has been slightly modified. The stems of the T-irons have been cut away so as to leave only the tables. These are opened out so as to include the eye of the tension rods and also the fork of the tie rod.

In place of the joint at the apex of the truss shown in fig. 285 a cast-iron head might have been used with an arrangement for tightening up the tension rods.

This is usually done by forming rectangular slots in the head, and ends of the tension rods. When the latter are in position these slots nearly coincide. A steel wedge or cotter is then driven in so as to draw the parts together, the friction being reduced by means of a gib on each side of the wedge.

P

Similar joints are sometimes used at the feet of the principal rafters.

Fig. 287 gives details of the joint at D, fig. 284. The web of the rafter passes into a cast-iron chair and is securely bolted in position. The tension rod passes quite through the chair, at the end of which, and cast with it, is a **facing** to provide a good bearing for the nut used to tighten up the truss. The rest of the figure explains itself.

147. A trussed rafter roof with three struts is shown in fig. 288, which has been drawn somewhat more elaborately than the previous truss diagrams in order to give an idea of the general appearance of a roof of this class.

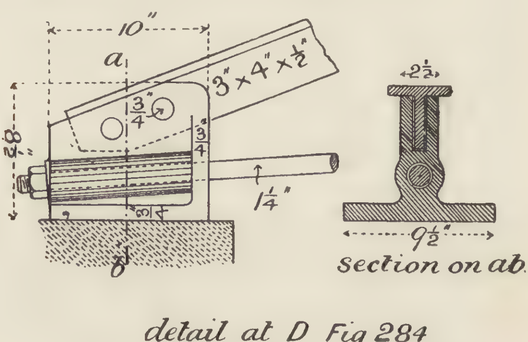


FIG. 287.

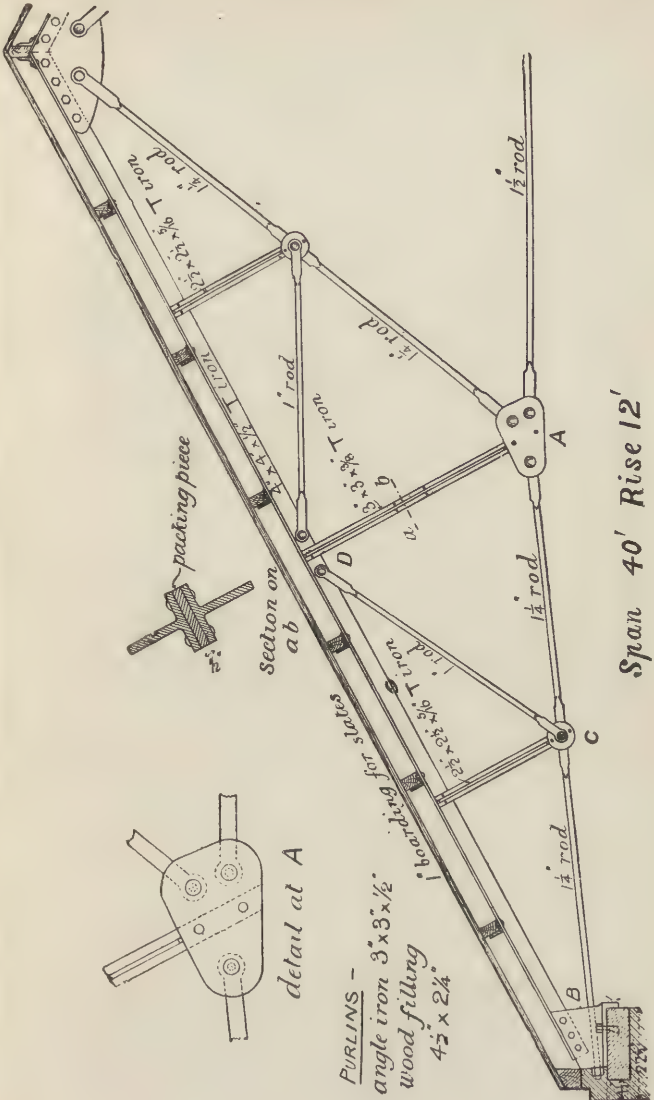
Each half may be said to consist of three distinct trusses similar to the one just described.

In the same figure is shown an enlarged detail of the joint at A. The two tension rods and the tie rod have **eyes** formed at the ends ; these are bolted through coverplates ⅝ inch thick

The main strut, which consists of two T-irons placed back to back with a half-inch space between them, and having the lower portions of the stems cut away, are riveted to the inside of the coverplates.

A wrought-iron packing piece is placed between the T-irons in the middle of the principal strut and riveted to them. A section is given to illustrate this.

An enlarged view of the wrought-iron chair at B, fig. 288, is



Span 40′ Rise 12′

FIG. 288.

shown in fig. 289. One side of the chair is movable, and is furnished with a joggle to assist in sustaining the thrust of the

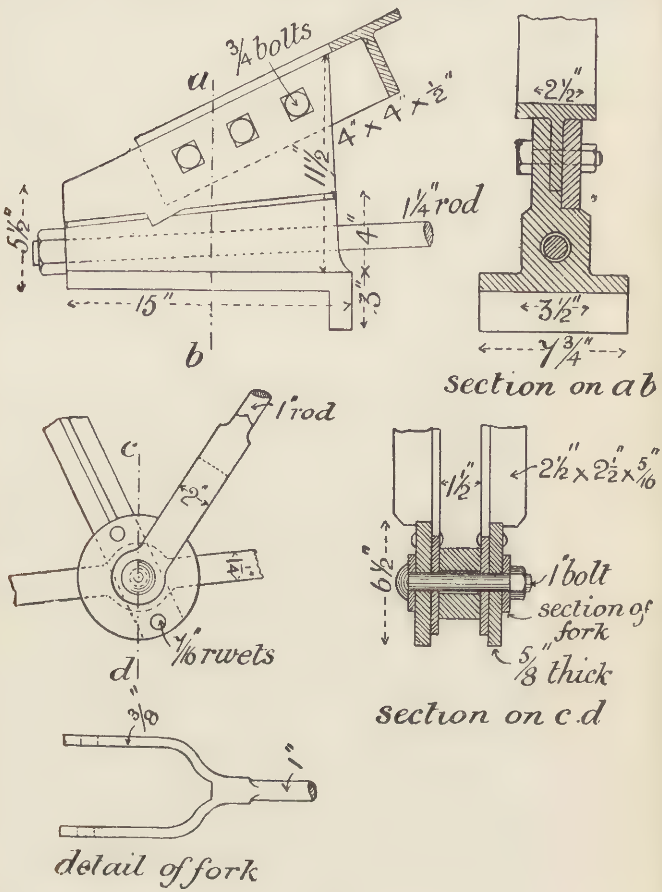


FIG. 289.

rafter. The back of the chair is inclined, and thus affords in itself a bearing for the nut used to tighten up the rod.

The same figure illustrates both in elevation and section the joint at c, fig. 288.

Fig. 290 is a detail at D, fig. 288.

In some cases the tie and tension rods in a roof of this kind are divided in the middle, an arrangement being adopted for tightening them up either by means of cottered joints or screw shackles.

One form of the latter is illustrated in fig. 291. The ends

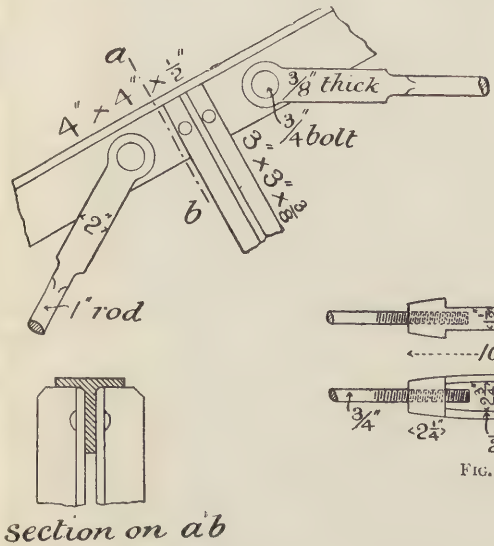


FIG. 290.

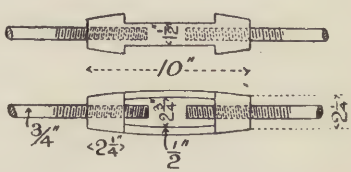


FIG. 291.

are tapped inside with reverse screw threads, corresponding threads being cut on the ends of the rods.

By turning round the shackle the ends of the rods may be thus drawn together.

Sometimes the shackle is solid and takes the form of a long hexagonal or octagonal nut.

EXERCISES ON CHAPTER XIII.

1. Draw to a scale of $\frac{1}{3}$ the details given in fig. 276 and show a section on the line *a b*.

2. Detail of a cast-iron shoe at the foot of a T-iron rafter. Draw to a scale of $\frac{1}{3}$, and give a vertical section through the centre of the bolt at the end of the tie rod.

3. Draw to a scale of $\frac{1}{24}$ the elevation of a little more than $\frac{1}{2}$ the truss given in fig. 275; the details of the joints and members to be shown.

4. Draw figs. 279 and 280 to a scale of $\frac{1}{3}$.

5. Draw complete in all its details the elevation of a little more than $\frac{1}{2}$ the roof-truss given in fig. 278. Scale, $\frac{1}{16}$.

6. Draw to a scale of $\frac{1}{3}$ the joints shown in figs. 282 and 283. Then give, to a scale of $\frac{1}{36}$, an elevation about $\frac{1}{2}$ the truss shown in fig. 281. All details are to be shown in the elevation.

7. Elevation of a common form of iron roof-truss, fig. 284. Draw to a scale of $\frac{1}{3}$ details of the joints at A, B, C, and D.

8. Draw to a scale of $\frac{1}{36}$ the truss illustrated in fig. 288. Give separate drawings to a scale of $\frac{1}{3}$ of the joints at A, B, C, and D.

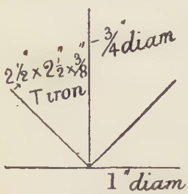


Fig. 292.

9. Joint at the foot of the king rod in an iron roof-truss, fig. 292. Give a detail drawing of the joint, $\frac{1}{4}$ full size, the struts being of T-iron 3″ × 3″ × $\frac{3}{8}$″, the king rod $\frac{3}{4}$″ round iron, and the tie rod of $1\frac{1}{4}$″ round iron.

10. A skeleton diagram of an iron roof-truss, fig. 293. Show by sketches the sections you would adopt for the members A, B, C, D, E. Also show the form of joint you would use at F, which must allow of tightening up.

11. Line diagram of an ordinary iron roof-truss, fig. 294. Draw to a scale of $\frac{1}{4}$ the joint at F, showing a cast-iron shoe bolted down to a 6″

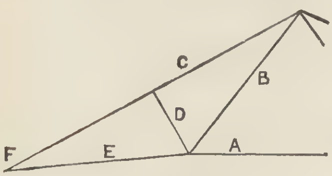


Fig. 293.

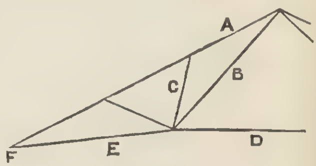


Fig. 294.

stone template resting on a 14″ brick wall. The principal to be 3″ × $2\frac{1}{2}$″ × $\frac{3}{8}$″ T-iron and the tie rod 1″ round iron, with an arrangement for tightening up. Give sections of the parts A, B, C, D, E. The sections need not be to scale.

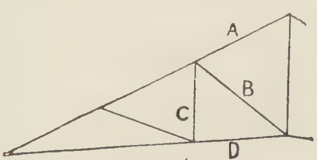


Fig. 295.

12. Skeleton diagram of a common form of wrought-iron truss, fig. 295. Give sections of the iron proper for the parts A, B, C, D, and state if any of them should be of cast iron rather than of wrought iron. The sections need not be to scale.

13. Skeleton diagram of a very common form of wrought-iron roof-truss, fig. 296. Give the sections of iron to be used for the parts A, B, C, D. They need not be dimensioned or drawn to scale.

14. Diagram of an iron roof, fig. 296. Give a sketch (freehand) of any method you know of for connecting the parts A, B, C, D, the dimensions of which are as follows:—A, $\frac{3}{4}''$ round iron; B and C, $1\frac{1}{4}''$ round iron; D, two flat bars, each $2\frac{1}{2}'' \times \frac{1}{2}''$, kept together by distance pipes, with bolts passing through them.

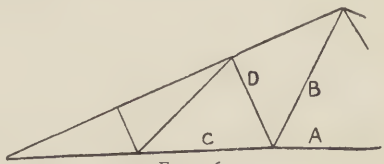


FIG. 296.

15. Supposing fig. 297 to be an iron roof-truss, show by sketches the form of section you would adopt for each member, and how you would construct the joint at the foot of the king rod.

16. Elevation of a vertical angle iron joined to a horizontal T-iron, fig. 298. Give sections, half full size, through A B and C D.

17. The foot of a T-iron principal rafter and the tie of the same roof truss are to be connected by means of a cast-iron shoe, resting on and

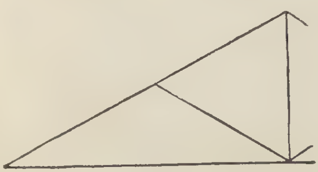


FIG. 297.

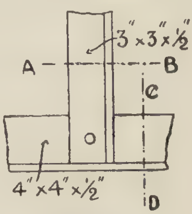


FIG. 298.

having a projecting stud let into a stone template on the top of the wall carrying the roof. The roof has a rise of $\frac{1}{5}$ the span, the T-iron is $2\frac{1}{2}'' \times 3'' \times \frac{3}{8}''$, and the tie rod is $1\frac{1}{8}''$ round iron. Give a drawing to a large scale of any form of shoe, and the connections with it, that you may be acquainted with.

18. Give an elevation, to a scale of $3'$ to an inch, of an iron roof-truss for a $20'$ span (a little over half the truss will be sufficient), with enlarged sketches, showing how the feet of the principals are supported on the walls.

CHAPTER XIV.

MATERIALS USED IN BUILDING CONSTRUCTION.

148. The consideration of building materials does not fall strictly within the limits of the elementary course. It has been thought advisable, however, to render this work somewhat more comprehensive by inserting a few remarks on the subject, leaving it to be minutely treated in a future volume.

The materials alluded to in the preceding pages are: **Brick, stone, mortar, plaster, cement, concrete, wood, iron, lead, glass,** and **asphalte.**

Brick.—The bricks used for ordinary building purposes are composed of **clay,** which, after being dug up, goes through a number of operations for the purpose of rendering it **homogeneous** and suitable for use, the number and character of these processes varying with the quality of the bricks required. The prepared clay is then moulded into the requisite form by **hand** or **machinery.**

After being **dried** (usually in sheds) the bricks are **burned in kilns or in clamps.**

The colour of a brick is mainly determined by—

(1) The presence of certain **metallic oxides,** etc.;

(2) The **degree of burning** to which the brick is subjected;

(3) The **chemical constitution of the clay.**

Red bricks owe their colour to the presence in the clay of **iron,** which in firing is converted into the red **ferric oxide,** Fe_2O_3.

If intensely heated, it becomes changed into the higher oxide, Fe_3O_4, which gives a **dark-blue** colouration.

In burning, several causes operate to render the bricks **unequal in quality.** They are therefore **sorted** into different classes. The names given to these vary with the locality of the brickfield.

It will be sufficient here to state that, as regards quality, the following classification may be made:—

(1) Malm cutters, or rubbers.
(2) Facing bricks.
(3) Stocks.
(4) Underburned or place bricks and clinkers.

Malm cutters, or rubbers, are made of a superior kind of clay carefully prepared. In burning they are not exposed to so high a temperature as ordinary bricks. This renders them soft, and, as their name indicates, capable of being cut roughly to the necessary shape. **Accuracy of form** and **smoothness** are afterwards obtained by **rubbing.**

For ornamental work **purpose made** bricks may now be obtained, and in exposed situations are preferable to cutters, owing to the softness and bad weathering qualities of the latter.

Facing bricks are **hard burned, well shaped,** and of **uniform colour.** In good work they are frequently used to give a superior appearance to the face of a wall.

Stocks are well-burned bricks of **average soundness** and **fairly uniform colour.**

In ordinary work the bulk of the walling would be laid with this class of brick.

Underburned bricks and **clinkers** are of the poorest quality, the former being **soft, weak,** and **easily disintegrated** on exposure to the weather. The latter are **overburned, shapeless,** and frequently **fused together.** In no good work should their use be tolerated. They are, however, often employed for foundations and the interior of walls.

The qualities of good bricks may be summarised thus: (1) Regular shape and uniform size; (2) absence of cracks, stones, etc.; (3) ringing sound when struck together; (4) uniform texture as exhibited by fractured surfaces; (5) absorption of not more than from $\frac{1}{6}$ to $\frac{1}{8}$ their weight of water.

The durability of well-burned brick places it in the front rank as a building material for general use.

Stone may be obtained that will be as durable, but it is rare. A brick made of good clay well burned is practically indestructible, except by a force that will crush it to fragments.

It is proof against all **chemical agents,** and, although it absorbs water quite freely, yet it has sufficient **elasticity** to endure expansion in freezing without injury.

All its component parts being perfectly insoluble, it will remain under water indefinitely without injury, and no degree of heat will affect it that will not fuse iron and destroy granite.

The following special varieties of bricks may be mentioned :—

Staffordshire blue bricks.—These are composed of clay containing a large percentage of **oxide of iron,** which is converted into the **black oxide** by intense heat, giving a characteristic dark-blue colour to the bricks.

Their qualities are : (1) Extreme hardness, (2) great durability, (3) non-porosity, (4) great compressive strength. This last renders them highly serviceable for **piers, jambs, arches,** etc.

White bricks are made of clay containing little or no iron. A proportion of fine **white sand** is added by some makers. If the clay contains sufficient iron to colour the brick when burned, it is mixed and ground up with **chalk** to counteract this effect. Some clays contain in their natural state the requisite amount of chalk to effect this purpose.

Glazed bricks.—These have an **enamelled surface,** which is easily washed, and are thus extremely valuable for **sanitary** purposes.

Fire bricks are composed of clay capable of sustaining, without fusing, a very high temperature. Their refractory nature is due to the presence of a large proportion of **silica.**

Terra-cotta.—This material may be classed with the preceding, but the clay used is much more carefully prepared, and the drying and firing are also required to be more gradual.

The chief difficulty experienced in its manufacture is the prevention of **warping** and **twisting.** As a substitute for stone it possesses the following advantages : (1) Durability, (2) hardness, (3) great compressive strength, (4) lightness.

149. Stone.—The durability of building stone depends very largely on the power which its chemical constituents have of resisting atmospheric influences.

In a large town one has not far to travel in order to witness the deleterious effects which **smoky air,** with its accompanying **acids** and **fumes,** has on this material.

As water is a medium by which these destructive agents may be conveyed into the substance of the stone, it follows that a dry atmosphere is conducive to the preservation of the latter. In the same connection may be mentioned the **disintegrating effect of frost.** Porous stone rapidly imbibes moisture. This in winter becomes frozen. The **expansion** which accompanies **freezing** causes the surface to flake away. Fresh surfaces are exposed, which in turn are destroyed in like manner. Thus a continual breaking down is going on. **Crystalline structures** are found to resist the effects of the weather far better than those which are **non-crystalline.**

Several preparations and processes have been devised of recent years for increasing the durability of building stone when exposed to the weather. These methods, although more or less successful, are none of them in general use, simply on account of their impracticability on a large scale.

They may be classified as follows: (1) The application of an **impermeable coating of organic matter,** *e.g.* oil, paint, etc., to the surface of the stone; (2) the **induration of the stone with a liquid** containing in solution a substance which either combines with one of the constituents of the stone to form an **insoluble compound,** or is **precipitated** as such by the double decomposition arising from the application of a second liquid to the surface of the stone. In either case the **pores are filled up,** and the surface is rendered **denser** by means of this precipitated matter.

No attempt will be made in these notes to give a description of the different processes, or of the chemical changes which occur. It will be sufficient to mention that in nearly all cases the object attained is the formation of an **insoluble silicate of lime.**

Mention has already been made in a previous chapter of the '**natural bed**' of stone; referring to the relative position in which it was formed by Nature.

Thus, stones of laminated structure (sedimentary rocks), such as **slate, sandstone, limestone,** etc., were originally deposited with the **grain** (as it is technically called) in a **horizontal** position. In using these stones, therefore, the laminæ

should, except in a few cases—*e.g.* undercut mouldings, cornices, etc.—be perpendicular to the pressure sustained.

For a geological classification of the different stones, or **rocks** as they are termed, the student is referred to the various handbooks on this subject. It will be sufficient for our purpose to briefly deal with those varieties used in building under the following heads :—

I. Igneous rocks	Granite. Porphyry.
II. Sedimentary rocks	Slate. Limestone. Sandstone.

Granite is a crystalline stone composed, radically, of **quartz**, **felspar**, and **mica**. The first of these is indestructible, and when present in large quantities renders the material extremely hard.

The durability of granite, while depending to a certain extent on the amount of quartz present, is largely determined by the character of the remaining constituents—viz. mica and felspar. These in some specimens of granite are liable to decay.

With regard to its physical structure, a fine granular composition is to be preferred.

Owing to its great hardness, granite is not readily worked. Its use is therefore costly, and consequently in ordinary building is restricted to such purposes as columns, plinths, dressings, strings, etc. For heavy work, such as bridge piers, sea-walls, lighthouses, etc. its durability renders its use a matter of necessity.

Slate.—This material is a clay rock, very fine-grained and dense in structure. One remarkable characteristic it possesses is the ease with which blocks may be split along certain **cleavage planes**, into thin sheets known as roofing slates.

Slate is also sent into the market in the form of thick **slabs** used for landings, steps, cisterns, mantel-pieces, etc. The finest slate is quarried in Wales.

The following qualities may be taken as characteristic of good slate: (1) Fine grain, (2) compactness, (3) sharp metallic ring when struck, (4) non-absorption of water, (5) even colour.

Limestone.—The essential constituent of this stone is **calcium carbonate** (carbonate of lime), associated in different varieties of the material with **iron, magnesium carbonate, silica**, etc.

The purest limestones are **marble** and **chalk**, the former being **crystalline**, the latter **amorphous** or **non-crystalline** in structure, and therefore useless for building purposes.

Since limestone is very quickly attacked by acid vapours contained in the air, it depends largely for durability on its density and compactness of structure.

The following varieties of limestone are in common use:—

Kentish Rag.—This is a dense, heavy material quarried in Mid-Kent. It is chiefly used for rubble walling, and, owing to its good weathering qualities, is well adapted for external work. **Paving sets** are often made of it.

Portland Stone is a granular limestone differing in quality although not in chemical composition according to its position in the quarry. That known as **whitbed** stone is considered to be the finest and the most durable. It is generally white in appearance, sometimes light brown, and weathers admirably. It is largely used for out-door work and internal staircases.

Bath Stone is mostly fine grained and of a colour ranging from white to light brown. Some varieties resist the weather well, others are more suitable for internal work. There is also considerable difference in the hardness of different specimens, the softer kinds being used for tracery and carving.

Sandstone.—This material is found in almost every variety of colour from white to black. The main constituent is **sand** (quartz), the grains of which are cemented together by such materials as **calcium** and **magnesium carbonates, ferric oxide, silica**, etc. The sand being indestructible, the durability of the stone depends on the weathering properties of the **cementing** materials.

The finest grained kinds of sandstone are employed for

carving ; the hard varieties for flagstones, steps, ashlar walling, dressings, etc.

Very many sandstone quarries exist in various parts of Great Britain and Ireland, yielding stone of different qualities.

The following sandstones among others are well known and frequently used :—

I. **York** (white, grey, brown, and yellow). II. **Bramley Fall** (light brown). III. **Forest of Dean** (grey). IV. **Mansfield** (red and white). V. **Craigleith** (light grey).

150. Mortar.—Ordinary mortar is formed by mixing together **lime, sand,** and **water,** and is used for binding together bricks or stones in building operations.

Lime is prepared by calcining **chalk** (calcium carbonate), usually in a kiln. During the process a gas known as carbon dioxide is driven off, leaving a white or light-brown mass of calcium oxide or **quicklime.**

This quicklime, on being mixed or **slaked** with the requisite amount of water, is converted into **calcium hydrate.** While combining with the water it gives out heat, cracks, and falls into powder. In this state it possesses a great affinity for carbonic acid, by the absorption of which it becomes reconverted into calcium carbonate.

Lime made from pure calcium carbonate is known as **fat** lime. It is unsuitable for good work, since that portion only which is exposed to the air hardens by absorbing carbonic acid. In addition, the moisture which it readily imbibes becomes frozen in winter, causing by its expansion the disintegration of the mortar surface.

Hydraulic lime is formed from impure calcium carbonate. As its name indicates, it solidifies by combination with a certain amount of water. This is due to the presence of **silica** and **alumina,** in the form of clay. Hence this form of lime is extremely valuable in **damp** situations or in positions **unexposed to the air.**

The **amount** of clay present determines its **hydraulicity** or **setting power.** In some cases when under water it will set firm in a few hours, and ultimately become as hard as a rock. This occurs when something like 25 per cent. of clay is

present. With a fifth of this quantity it never becomes really hard.

In preparing mortar the quicklime must first be slaked. A certain quantity of it is placed in a heap and sprinkled with water. Salt water should not be used, owing to the deliquescent nature of the **salts** contained in it.

The requisite amount of **sand** is then added to the lime, and after a sufficient time has elapsed for the thorough slaking of the lime the heap is turned over, and the ingredients thoroughly mixed, water being added from time to time so as to form the mortar into a stiff mass. This process is on large works performed in a **mortar mill,** the incorporation of the materials being brought about by the grinding action of two heavy revolving rollers and a rotating pan. The proportions of lime and sand vary with the nature of the work.

The following are taken from specifications :—

(1)

Dorking greystone lime (fresh burned) .	1 part by measure.
Clean sharp river (or pit) sand . .	2 parts ,,

(2)

Grey lime	1 part ,,
Portland cement	1 part ,,
Clean sharp river (or pit) sand . .	5 parts ,,

In the latter case Portland cement is added to give strength. This is frequently done in the case of weak limes.

In using mortar the surfaces to be cemented together should be thoroughly wet. This should be especially attended to in the case of **hydraulic limes** and **cements**, since their solidification depends to a great extent on the absorption of water and the consequent formation of **hydrated silicates**. With dry dusty surfaces the moisture is sucked out of the mortar.

151. Cement.—This differs from lime in containing large proportions of silica and alumina. It consequently sets much more quickly than the latter. It does not **slake** on the addition of water, thus contrasting with lime, which under the same circumstances is rapidly changed into hydrate of calcium.

Among the well-known cements are: Roman cement, Portland cement, Keene's cement, and Parian cement.

152. Concrete is a material formed by intimately mixing together **lime** or **cement, sand, broken bricks, stone,** or any hard material procurable, and **water.**

The cementing portion of the compound is termed the **matrix,** and the hard broken material the **aggregate.**

The following proportions for the ingredients have been gathered from specifications :—

(1)

Quicklime	1 part
Sand	2 parts
Broken brick, stone, or gravel, etc. . .	5 parts

(2)

Portland cement	1 part
Thames ballast—i.e. sand and shingle. .	7 parts

The materials are sometimes measured out in **barrow loads.** In other cases wooden boxes of sizes proportionate to the relative quantities of the ingredients are used. After these ingredients have been thoroughly mixed together in a dry state, the heap is sprinkled with water and turned over several times.

Some authorities recommend that the aggregate should not be added until the materials constituting the matrix are thoroughly incorporated with each other. In certain cases this plan has its advantages. If adopted, care should be taken that the aggregate is thoroughly wetted, otherwise it will imbibe moisture from the mortar.

After being thus prepared, the concrete should be tipped from a height of about 3 feet into position, and rammed down in layers from 9 to 12 inches thick.

Of recent years concrete has been employed for many purposes. Among these may be mentioned—foundations, walls, arches, steps, lintels, window-sills, etc.

153. Iron.—This metal exists in three modifications—viz. **cast iron, wrought iron,** and **steel.**

The differences, chemically and physically, between these three varieties are due to the fact of their containing varying proportions of **combined carbon**, as follows :—

Cast iron	2 to 5 per cent.
Wrought iron . . .	up to ·5 ,,
Steel	from ·2 to 1·8 per cent.

Cast iron is produced by remelting crude pig iron obtained by smelting iron ores in a blast furnace. Owing to the large percentage of carbon it is readily fusible.

Castings are formed by running the molten metal into **moulds** of **sand** or **loam.** In order to form these moulds, a **pattern** of the object required has to be made in wood, **mahogany** being generally selected for small patterns, and **yellow pine** for large.

The shrinkage of cast iron in solidifying amounts to $\frac{1}{8}$ of an inch per linear foot. It is necessary, therefore, to allow for this in making the pattern, which should be $\frac{1}{96}$ larger in every direction than the ultimate dimensions of the casting. Cast iron has little **tensile strength**, but offers great resistance to **compression.** It is hard and brittle, and when ruptured gives way suddenly without warning.

Among the uses to which this material is put by the builder may be mentioned—Columns, gutters, rain-water pipes, railings, portions of iron roofs—*e.g.* struts, shoes, heads, etc.

At one time it was largely used in the manufacture of girders. But recent improvements in the manufacture of rolled iron have caused the latter material to supplant it to a large extent for this purpose.

Wrought iron is obtained from cast iron by oxidising its carbon, thus removing it in the form of carbon-dioxide. The decarbonised, or wrought metal, is afterwards submitted to several processes, amongst others, **rolling.** This gives it a fibrous structure, and renders the material tough. Pure wrought iron contains no carbon. Practically, however, there is present a small percentage of this element, not exceeding ·25 per cent.

Unlike cast iron, it is with difficulty fused. But when heated

sufficiently it can be forged, welded, and rolled into any desired shape.

Wrought iron is inferior to cast iron in compressive strength, but its resistance to tension is about four times as great as that of the latter.

In addition to this, it has the excellent quality of giving way gradually when fractured, instead of suddenly snapping. These qualities render it an admirable material for tie-rods, bolts, straps, beams, etc.

It is sent into the market in many convenient forms—*e.g.* (1) **bar iron** of all sections, **round, half-round, oval, half-oval, octagon, square,** etc., (2) **angle iron,** (3) **T-iron,** (4) **channel iron,** (5) **rolled joist iron,** (6) **plain** and **corrugated sheet iron,** (7) **hoop iron,** etc.

Steel.—With this material the builder has little to do, beyond its use in the form of tools. Steel contains a larger proportion of carbon than wrought iron, but less than cast iron. Its characteristic properties are due in part to the presence of other substances besides carbon.

Speaking generally, steel is manufactured (1) by adding the necessary amount of carbon to wrought iron, or (2) by decarbonising molten pig iron to a certain degree, leaving the proper proportion of carbon in the metal.

There are several processes employed for effecting the conversion of iron to steel, resulting in the production of the following varieties of the metal—viz. **blister** steel, **shear** steel, **cast** steel, **puddled** steel, **Bessemer** steel, **Siemens-Martin** steel, etc.

The most important property of this material, and one rendering it simply invaluable for the manufacture of tools, is its capability of being **hardened** and **tempered.**

If steel at a red heat be plunged into cold water it becomes exceedingly hard.

The **more rapidly** it is cooled the **harder** it becomes. At the same time it becomes excessively **brittle,** and in this state is useless for the majority of purposes. If, however, the hard steel be re-heated, it will lose its hardness as its temperature rises, regaining it on cooling.

Hence all that is necessary is to gradually heat the steel to a degree fixed by practice for the particular purpose to which it is to be applied, and then plunge it into cold water. Where a very soft temper is required, the steel may be cooled more slowly in ashes, sand, etc.

The following table is intended to give the student some idea of the comparative strengths of ordinary cast iron, wrought iron, and steel, when subjected to tension and compression. It must be borne in mind that the strain per square inch of sectional area which a test-bar of any of these materials will bear depends to a large extent on the conditions under which the strain is applied.

The figures given below have been calculated for dead loads, and are averaged from the results of a large number of experiments :—

Nature of strain	Cast iron	Wrought iron	Steel
	Tons per sq. inch	Tons per sq. inch	Tons per sq. inch
Tension :			
Breaking strain . . .	7·5	22	32
Safe working strain . .	1·5	5	8
Compression :			
Breaking strain . . .	42	18	50
Safe working strain . .	7·5	4	12

Copper is a **red** coloured **malleable tenacious** metal used by the builder for a variety of purposes, chiefly in positions where iron cannot be employed owing to its liability to corrosion. Dowels and cramps for connecting stonework, slating nails, lightning conductors, etc., are generally made of this material, and occasionally roofs are covered with the sheet metal.

When exposed to the action of moisture and the carbon dioxide present in the air, it becomes coated with a film of **green copper carbonate**, commonly but incorrectly known as **verdigris**.

Lead is a metal largely used in building operations for covering **flat roofs, gutters, ridges, cisterns, pipes,** etc.

It is **bluish grey** in colour, very **soft** and **malleable, readily melted,** but of very **inferior tenacity**.

Q 2

Sheet lead is frequently placed between the bottom flange of a girder and the stone template on which it rests. Owing to its softness, it adapts itself readily to any irregularity in one or the other, thus forming a good bed for the end of the girder.

There are two forms of sheet lead obtainable in the market —viz. **cast** and **milled.**

Cast lead is sent into the market in sheets about 18 feet long and 6 feet wide, weighing as a rule something like 7 lbs. per superficial foot. Owing to its surface being harder than that of milled lead, it is better able to resist the effects of exposure. At the same time, in consequence of its thickness, it is not so easily worked as the latter.

Milled lead has a much more even surface than the variety just described, and can be obtained in sheets about 30 feet long and 7 feet wide, weighing from 1 to 9 lbs. per square foot. Milled lead is now almost always used for roof-work, but, as before mentioned, it is not so durable as cast lead, owing to the fact that in rolling the natural disposition of the atoms is altered.

In specifying sheet lead for particular purposes its weight in pounds per square foot is usually given, thus :

Aprons . .	5 lbs. lead	Ridge coverings .	6 lbs. lead
Flashings . .	6 ,,	Gutters . .	7 ,,
Hips coverings .	6 ,,	Flats . .	7 ,,

154. Zinc.—This metal is coming very largely into use for roof covering, gutters, rain-water pipes, etc.

Slating nails are made of it, and ironwork is, by the process known as **galvanising,** frequently covered with a thin coating of this metal, to prevent it from rusting.

Zinc can be easily melted, and when cold is very brittle. It is hardened by rolling, and when exposed to the air becomes coated with a grey film, consisting of the oxide and carbonate of the metal.

It expands and contracts under changes of temperature to a greater extent even than lead, and should, therefore, never be rigidly secured to the woodwork of a roof.

155. Wood.—Before discussing the various kinds of timber

and their properties, it will be as well to glance at the general structure of a tree and its mode of growth.

If the trunk of a fir or oak tree be cut across, it will, on examining the section, be found to consist of numerous concentric **annual rings**, arranged fairly symmetrically round a central column of **pith**, while an outer covering of **bark** encloses the whole.

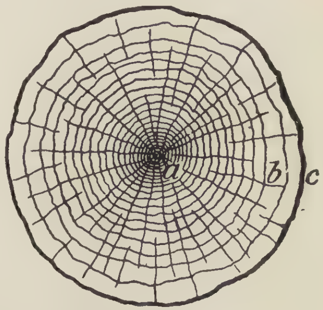


FIG. 299.

Radiating from the pith to the bark will be noticed a series of **medullary rays**, serving as **radial ties** connecting the outer annual rings with those at the centre of the tree.

These medullary rays, which, when cut through obliquely, give the wood that appearance known to the carpenter as **silver grain**, play an important part in the seasoning of timber to be described presently. The annual rings are tubular in structure. Briefly, the growth of a tree may be thus summarised.

(1) **Spring.**—Ascent of the sap into the leaves, where it loses moisture and gains carbon owing to the absorption of carbon dioxide from the air by the leaves.

(2) **Summer.**—Full development of the foliage; vegetation comes to a standstill.

(3) **Autumn.**—Descent of the sap from the leaves between the bark and the wood, where it deposits its accumulated carbon in the form of a woody ring, the leaves dropping off at the same time.

(4) **Winter.**—No flow of sap; vegetation is at a standstill.

This cycle of events occurs regularly year after year, a fresh layer or ring of woody tissue being added every autumn.

These rings harden by age. Thus we find that the central portion or **heartwood** of a tree is always firmer, stronger, and more durable than the recently deposited **sapwood**.

The student will readily understand that the best times for

felling timber are **mid-summer** and **mid-winter**, since at these periods the sap is not in motion.

After being felled, some method must be resorted to of getting rid of the sap remaining in the tree. This, known as **seasoning**, is performed in various ways. Amongst others may be noted :

(1) **Air or natural seasoning**, which consists in piling the timber so that the **logs**, or, what is better, **boards**, may be exposed to a free circulating current of air, while at the same time it is protected from the sun and rain.

(2) **Hot-air seasoning**, effected by simply drying up the sap by means of hot air in an oven.

(3) **Water and air seasoning**, in which the timber is placed under water as soon as possible after felling, in order that the bulk of the sap may be washed out. The seasoning is then completed by stacking the wet timber in a manner similar to that employed in the first method described, and allowing it to dry in the open air.

The object aimed at in each of these processes is the elimination of all moisture from the tree.

In consequence of the sap becoming dried up in the tubes composing the woody tissue, these collapse and lose their circular shape, causing an alteration in the **volume** and **form** of the timber. Now, this **shrinking** will take place in that direction in which the least resistance is offered. Owing to the presence of the medullary rays, the shrinkage cannot take place from the circumference to the centre.

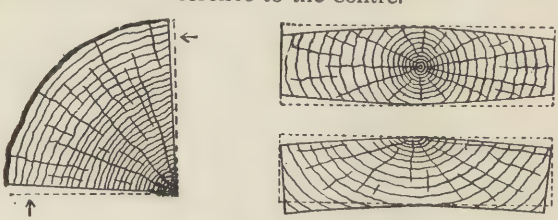


FIG. 300.

Consequently the fibrous tubes composing the wood collapse in a direction **at right angles to the medullary rays**.

The student will now understand why it is that alteration

in the shape of timber takes place during seasoning. In fig. 300 the dotted lines denote the original forms of the pieces.

The following terms are applied to some of the different forms into which timber is reduced before being sent into the market :—

Balk timber.	The trunk roughly squared with an axe.
Planks .	Pieces 11 inches wide, not more than 6 inches thick, and of variable length.
Deals . .	Pieces 9 inches wide, and not more than 4 inches thick.
Cut Deals .	Pieces 9 inches wide, and less than 2 inches thick.
Battens .	Pieces 7 inches wide, and not more than 4 inches thick.

The preservation of timber.—Several causes operate to bring about the decay of timber. Among the more conspicuous of these are—(1) **Wet rot,** (2) **dry rot.** The former occurs in the living tree, and is due to the action of moisture, which causes decomposition of the woody tissue with consequent liberation of certain gases.

Dry rot is the result of **insufficient ventilation, moisture,** and **warmth.** Its presence is indicated by the growth of a rapidly spreading **fungus** on the surface of the timber. This fungus eats into the woody tissue, rendering it **brittle,** and finally reducing it to **powder.** It is particularly liable to appear on the timber of ill-ventilated **floors** and on woodwork **built into walls.**

There are several means of preserving timber from decay, depending on the perfect exclusion of moisture. The following are among the number :—

(1) **Painting** and **tarring,** which need no description.

(2) **Creosoting,** which consists of extracting all the air and moisture from the wood and replacing them with **creosote** forced in under pressure.

(3) **Impregnating** the timber with **solutions of certain metallic salts**—*e.g.* **sulphate of copper, chloride of zinc,** etc.

(4) **Charring** the surface of the timber. This is frequently done when the timber has to be put into the ground, as in the case of **posts, railway sleepers,** etc.

Varieties of Timber.—The different kinds of wood may

be classified as follows: (1) **Soft wood**, containing **resin**—*e.g* pine, fir, spruce, larch, etc. (2) **Hard wood**, which is **non-resinous**—*e.g.* oak, ash, elm, beech, mahogany, teak.

Pine.—The material known to carpenters as red and yellow **fir** or red and yellow **deal** is in reality pine wood, not fir. The *Pinus Sylvestris*, from which it is obtained, grows in the North of Europe. The wood varies in colour with the character of the soil on which it is produced, being generally red or golden yellow. The annual rings vary in thickness, each consisting of two portions, one **dark** the other **light** coloured.

This timber is easily worked and is fairly durable. The following market varieties are imported in scantling:—

Dantzic timber .	Strong, light coloured, elastic, and knotty.
Riga ,, .	Free from knots, and straight grained.
Memel ,, .	Similar to that from Riga.
Swedish ,, .	Soft, yellowish white, and straight grained.

Red and yellow deals are sent into the market from the following ports:—

Memel and Dantzic	Durable, and suitable for exterior work.
St. Petersburg .	Largely used in good work for floors and general joinery.
Christiania . .	Chiefly the yellow wood, and often sent over already worked up into match-boarding and flooring battens.
Gefle, Stockholm, and other Swedish ports.	As a rule this is of poor quality, containing a deal of sap, and readily warping. The superior varieties, however, are in great request.

American red pine is grown in Canada. It is light red in colour, very durable, strong, and fine grained.

American yellow pine is dark yellow in colour and has a soft, silky surface. A characteristic appearance is given to this wood by the presence of thin dark lines running along the grain.

Pitch pine comes from America. It is reddish yellow in colour, and when worked up is beautifully figured. This timber is very resinous, hard and heavy. Its durability fits it for such purposes as flooring, window sills, etc. Pitch pine is largely used for joinery and ornamental wood-work.

Spruce.—This is sometimes known as **white fir**, while the carpenter speaks of it as **white deal**. It is a tough, knotty wood, inferior to red and yellow deal in durability and strength. White deal is used mostly for cheap joinery, floor boarding, panels, and general rough work. It is exported from Christiania, Onega, Riga, etc.

Larch is imported from Russia and other parts of Northern Europe and America. The wood is brownish yellow in colour, tough, and very durable. It is sometimes used for stairs, floor boards, etc.

Oak is grown in England, Russia, America, and other parts. That grown in our own country is considered to be the most durable. It is light brown in colour, and has a very hard, dense surface. It is exceedingly tough, and is used for almost all purposes where durability and strength are required. Door and window sills, stair treads, etc., are made of this material.

Russian oak is dark brown in colour and fairly durable. Its grain is close, and as a rule it is free from knots. This wood is shipped from Riga. Hence it is generally termed **Riga oak**.

Dantzic oak, named from its port of shipment, is similar in appearance and properties to that previously mentioned.

American oak is exported from Canada and the United States. It is pale reddish brown in colour, coarser in grain than English oak, hard, tough, and in point of durability ranks next to the British-grown timber.

Ash.—This wood is grown in our own country, America, etc. Its colour is brownish white. On examining an end section of the wood it will be noticed that the annual rings are separated by layers of porous tissue. This timber is valuable on account of its toughness, elasticity, and flexibility. Owing to these properties it is largely used for shafts, wheels, handles of tools, etc.

Elm.—Several varieties of this tree grow in England and other parts of Europe varying in colour from reddish brown to brownish white. That known as the **common English elm** is exceedingly fibrous and tough, and if kept either constantly dry or wholly beneath water is very durable. It is largely used in positions where it is always wet—*e.g.* pump buckets, ships' planks, coffins, piles.

Beech.—This tree grows in all the temperate parts of Europe and also in America. The colour of the wood ranges from dark to whitish brown, according to the soil in which it is grown and its situation. It is compact, fine grained, hard, and has a very smooth surface. When exposed to wet and dry alternately it quickly decays. If, however, it be kept continually wet or always dry, the wood is very durable.

It is much used for piles, carpenters' planes, mallets, and cogs for mortise wheels.

Mahogany is imported from Honduras, in Central America, and that variety known as Spanish mahogany from the West Indies. The former is reddish brown in colour, generally straight grained but sometimes figured—i.e. wavy grained.

This material is not adapted for outdoor work, since it does not weather satisfactorily. Nevertheless, it is frequently used for window sashes. Handrails are also made of it. When carefully seasoned, it does not warp or shrink to any great extent.

Spanish mahogany is valuable for ornamental purposes on account of its beautiful figure. The chief peculiarity of its structure is the **chalky substance** contained within the pores of the wood.

Teak is found chiefly in Further India. Its colour is yellowish brown and its grain is fine and straight. It requires care in working, since it easily splinters. An aromatic oil contained in the pores of this wood renders it very durable and free from the attacks of insects, while at the same time it prevents the rusting of any iron with which the wood may be in contact. Though costly, it is sometimes used in the place of oak.

There are several other kinds of timber occasionally used by the builder, such as **sycamore, cedar, cypress, Kawrie, pine, chestnut, walnut**, etc. These will be described in a future volume.

The following table shows some of the purposes to which different kinds of wood are applied in ordinary building construction :—

Kind of wood	Uses to which applied
Baltic red and yellow pine.	Wall plates, joists, sleepers, roofing timber, flooring, match-boarding, sashes, window and door frames, partitions, grounds, wall battens, exterior doors.
Baltic white fir (*spruce*) .	Interior doors, paneling, carpentry, flooring, cheap joinery.
American red pine . .	Interior joinery, backing for veneer, etc.
American yellow pine .	Paneling, interior joinery, patterns.
Pitch pine . . .	Interior joinery and ornamental work, floors, window sills, framing in carpentry where great strength is required.
Oak	Stair treads, window sills, floors, framing in carpentry, superior joinery.
Mahogany . . .	Patterns, window sills, interior joinery and ornamental work.
Teak	Floors, stair treads.

APPENDIX A.

BOARD OF EDUCATION.

SYLLABUS.

SUBJECT III.—BUILDING CONSTRUCTION AND DRAWING.

The instruction given should be so arranged that by the time the student finishes his course of study, he should have acquired a knowledge of building materials, plant, and construction, sufficient for the work upon which he is likely to be engaged. That he may be able to make free use of this knowledge in practice, he must also be a good draughtsman; good drawing is an essential part of the course, but it must always be borne in mind that drawing is a *means* and not an end in itself; drawings of work to be carried out should be such as to give full information and exact guidance to workmen who may have to use them. In the higher stages of the subject students should acquire proficiency in making finished drawings, as well as what may be called descriptive and explanatory drawings.

A larger number of questions will be set in the examination papers than the candidate will be allowed to attempt, so that he may have some

range of selection of questions which bear upon branches to which he has given special attention.

Compulsory questions may be set at the examinations.

It should be seen that candidates are fairly provided with pens, ink, pencils, and drawing instruments (including tee and set squares, drawing boards, Indian ink, etc.) when they present themselves for the examination. The use in examination of the ordinary boxwood, ivory, or paper scales and protractors, and slide rules, is permitted.

STAGE 1.

In Stage 1, the drawing exercises should not extend beyond descriptive and explanatory drawing, but they should aim at cultivating a fair degree of skill in pencil drawings. All lines should be neat and clear. Students who are quick in executing their pencil drawings should practise making ink tracings with clear lettering and figuring.

All students should practise freehand drawing of details, so that they may be able readily to make a neat dimensioned sketch from which a drawing to scale might afterwards be prepared, or which may itself be sufficient for purposes of explanation. The use of squared paper may be introduced with advantage in exercises of this kind.

The course should include elementary instruction with reference to the various materials used in building. Each group of materials should be taken up in the class as introductory to a series of drawing exercises, illustrating their use in buildings so far as suitable for discussion in a first year's course. There would fall to be considered in this way: the nature and properties of sand, lime, and cement; the composition of mortar or concrete and its application in floors, walls, etc.; the properties of bricks, stones, tiles, and slates; the various kinds of timber in ordinary use; the constituents of cast-iron, wrought-iron, and steel, and the essential or characteristic differences of their properties.

Instruction should be given as to foundations in ordinary soils, footings for walls of moderate height; the construction of simple scaffolding; the various bonds of brickwork in plain walling, flues, arches, and fire-places; varieties of simple masonry such as rubble and ashlar walling and the plain masons' work on sills, reveals, etc.; plain carpentry in floor joists, stud partitions, ordinary roofs of span not exceeding that for a king-post truss; firrings of flats; simple joiners' work in floor-laying, skirtings, deal-cased frames and double-hung sashes, and solid frames for simple casements, panelled doors and jamb linings, door frames and ledged and braced doors; ordinary plastering on walls, partitions, and ceilings, and the composition of the various coats; slating, including the dressing, cutting, and nailing of the slates; plain tiling and pan tiling and the various methods of hanging the tiles, and the treatment of valleys, hips, ridges, and eaves; roof plumbing, including the laying of flats with rolls, drips, etc., lead gutters, and flashings; simple glazing. Students should also be taught how to draw the sections of rolled joists, channels, angles, and tees.

In all these subjects practical examples of the materials used and the various operations of dealing with them should be brought before the student, either in the classroom or elsewhere; in as many cases as possible, he ought actually to see and handle full size examples of everything in which he is being instructed theoretically. He should also familiarize

himself with the nature and use of all the tools used in elementary building operations. Students should lose no opportunity to inspect any building operations going on in their locality. Every student ought to examine in detail the structure of the houses in which he lives and works and attends classes.

APPENDIX B.

EXAMINATION PAPERS SET IN THE YEARS 1895—1906, BY THE SCIENCE AND ART DEPARTMENT AND THE BOARD OF EDUCATION, SOUTH KENSINGTON.

SUBJECT III.—BUILDING CONSTRUCTION.

GENERAL INSTRUCTIONS.

If the rules are not attended to, the paper will be cancelled.

Immediately before the Examination commences, the following

REGULATIONS ARE TO BE READ TO THE CANDIDATES.

Before commencing your work, you are required to fill up the numbered slip which is attached to the blank examination paper.

You may not have with you any books, notes, or scribbling paper.

You are not allowed to write or make any marks upon your paper of questions, or to take it away before the close of the examination.

You must not, under any circumstances whatever, speak to or communicate with one another, and no explanation of the subject of examination may be asked or given.

You must remain seated until your papers have been collected, and then quietly leave the examination room. None of you will be permitted to leave before the expiration of one hour from the commencement of the examination, and no one can be readmitted after having once left the room.

Your papers, unless previously given up, will all be collected at 10 o'clock.

If any of you break any of these rules, or use any unfair means, you will be expelled and your paper cancelled.

Before commencing your work, you must carefully read the following instructions:—

You are permitted to answer only seven questions.

Drawings must be made on the single sheet of drawing-paper supplied, beginning on the side marked with your distinguishing number, which must face you at the right-hand top corner. *Sketches* may be made by hand on the squared paper attached to the drawing-paper. Additional foolscap will, if necessary, be supplied to you by the Superintendents.

The tracing is to be drawn on the piece of tracing-paper attached to the drawing-paper.

Answers in writing must be as short and clearly stated as possible, and the references to drawings and sketches must be made absolutely clear by letters or numbers.

The value attached to each question is shown in brackets after the question. But a full and correct answer to an easy question will in all cases secure a larger number of marks than an incomplete or inexact answer to a more difficult one.

Questions marked (*) have accompanying diagrams.

The Examination in this subject lasts for four hours.

FIRST STAGE OR ELEMENTARY EXAMINATION, 1895.

Instructions.

You are only permitted to attempt *seven* questions.

Note.—*The diagrams connected with these questions will be found in fig.* 301.

*1. Plans of two successive courses of a brick pier.
Draw, to a scale of 1″ to a foot, showing the bricks laid in English bond. (11.)

*2. Section of a dwarf brick wall.
Draw to a scale of $\frac{3}{4}$″ to a foot, showing the joints of the brick-work below the ground, adding the footings and a proper stone saddle-back coping 17″ wide. (11.)

*3. Elevation of part of the end of a stone building, in irregular coursed or snecked rubble, the quoins being hammer dressed with drafted margins.
Draw, to a scale of $\frac{3}{4}$″ to a foot. (11.)

*4. A and B show two bed joints in Ashlar work.
Draw A, showing the meaning of a hollow joint, with its probable results.
Draw B, showing the probable effects of a slack joint at back, packed with spalls. (11.)

*5. Sections of the sill and one of the studs of a lath and plastered framed partition.
Draw, to a scale $\frac{1}{4}$ full size, a vertical cross section of the joint at the foot of the stud.
State what distance you would place the studs apart, and why. (12.)

6. Give a cross section, to a scale of $\frac{1}{3}$ full size, through four $1\frac{1}{4}$″ floor battens, showing the following joints—rebated—rebated and filleted—ploughed and tongued. Put its tongue against each. (12.)

*7. Section of the lower half of a cast-iron girder 14″ deep.
Draw, $\frac{1}{4}$ full size, making any alteration you think necessary, and adding the upper part of the section. (12.)

*8. The details of an iron roof truss, for a 25-feet span.
Give, to a scale of $\frac{1}{30}$, an elevation of at least half of the truss. (13.)

9. Draw, to a scale of $\frac{1}{12}$, the back elevation of the head of a 3-feet

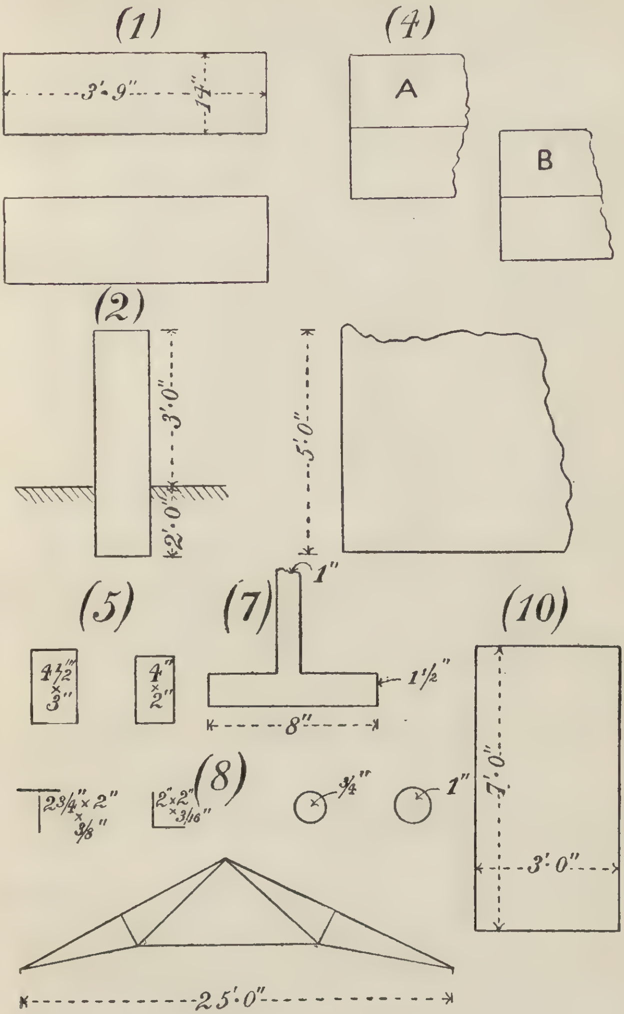


FIG. 301.

window opening in a brick wall, with $4\frac{1}{2}''$ reveals, a plain stone head, wood lintel, and common discharging arch.

The joints of the brickwork to be shown only on the right half of the elevation. The bond to be English. (13.)

*10. Elevation of a 6-panel door, framed square and flat.

Draw, to a scale of $\frac{3}{4}''$ to a foot, showing all the details of construction, and writing their names on the different parts. (14.)

11. Give, to a scale of $\frac{1}{18}$, a cross section through 2 girders of a framed floor constructed as follows:—

Girders, $12'' \times 10''$, and $8'$ apart.
Binders, $8'' \times 5\frac{1}{2}''$.
Bridging joists, $6'' \times 2''$.
Ceiling joists, $3'' \times 2''$. (14.)

12. Give a vertical cross section, to a scale of $\frac{1}{6}$, showing, both in section and elevation, all the details of a $1\frac{1}{2}''$ centre pivoted swing sash, with a $3'' \times 2\frac{1}{2}''$ solid frame set in a $9''$ brick wall. The sash to be $2'\ 3''$ high, and shown half open. (15.)

13. Draw, to a scale of an inch to a foot, a vertical cross section through the eaves of a wooden roof, showing the end of the truss carried on a $9''$ wall. Scantlings as follows:—

Wall plate, $4\frac{1}{2}'' \times 3''$.
Tie beam, $10'' \times 5''$.
Principal, $5'' \times 4''$.
Pole plate, $7'' \times 4''$.
Rafters, $4'' \times 2''$.

Three courses of Countess slates to be shown centre-nailed on $2\frac{3}{4}'' \times \frac{3}{4}''$ battens.

The eaves to be finished with a $4''$ half round gutter secured to a $\frac{3}{4}''$ deal fascia board. (15.)

14. Draw, $\frac{1}{4}$ full size, a horizontal section through one side of a sash frame in a $14''$ brick wall, including the stile of the lower sash, which is to be $2''$ ovolo moulded.

Put their names against the different parts. (16.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1896.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

NOTE.—*The diagrams connected with these questions will be found in fig.* 302.

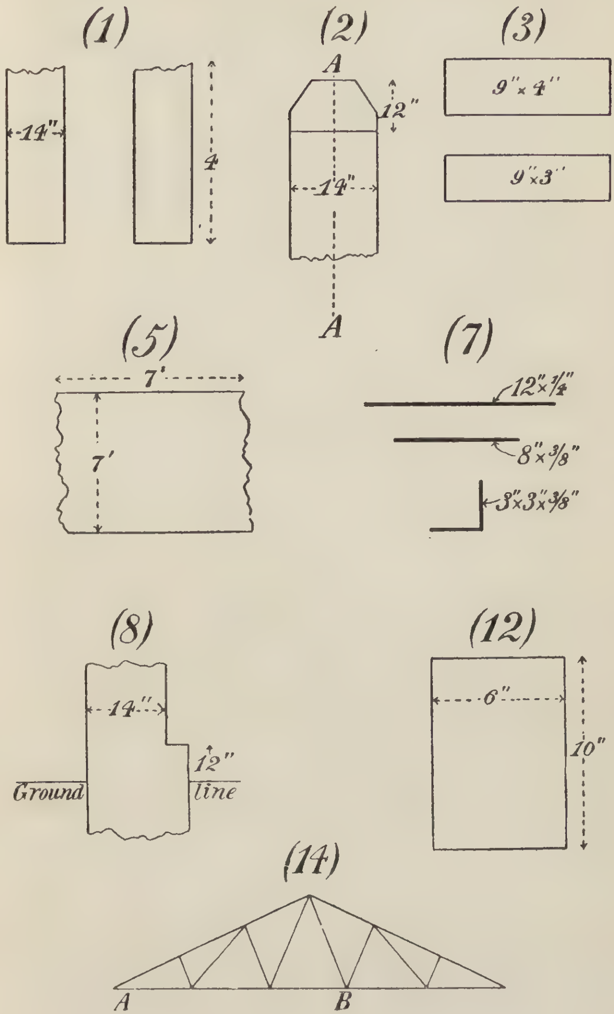
*1. Plans of two consecutive courses at the end of a brick wall built in Flemish bond.

Draw, to a scale of $\frac{1}{12}$, showing the joints of the brickwork, and marking by thick lines any portions of the joints which run unbroken down the wall. (11.)

*2. Vertical cross section of a wall with a stone coping.

Draw, to a scale of $2''$ to a foot, a longitudinal section through AA, showing the coping stones cramped together, and the joints of the two top courses of bricks, laid in English bond.

State the materials you would prefer to use for the joint. (11.)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(2)
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A
(3)
9"×4"
9"×3"
(5)
7'
7'
(7)
12"×1/4"
8"×3/8"
3"×3"×3/8"
(8)
14"
12"
Ground
line
(12)
6"
10"
(14)
A
B

FIG. 302.

*3. Sections of a trimmer and a bridging joist for a single floor.

Draw, to a scale $\frac{1}{4}$ full size, a cross section through the trimmer, showing the details of the joint between it and the bridging joint. (11.)

4. A timber beam, 12″ × 14″, is to be strengthened by a $\frac{3}{4}$″ iron flitch.

Give, to a scale of $\frac{1}{6}$, a cross section of the finished girder, showing the annual rings of the timber, also a part elevation sufficient to show the arrangement of the bolts. (11.)

*5. Part elevation of a stone wall built in random rubble, and at A a lacing course of three courses of bricks laid in Flemish bond.

Draw to a scale of $\frac{1}{2}$″ to a foot. (12.)

6. Show clearly, by sketches, the meaning of the following terms :—

Match boarding.
Flush bead.
Lead tingle.
Doubling eaves course. (12.)

*7. Give, to a scale $\frac{1}{4}$ full size, a cross section of a wrought-iron girder built up of the sections indicated by the line diagrams.

Show a part elevation, about 9″ long, with the rivets at a 4″ pitch. (12.)

*8. Cross section of the lower portion of the brick wall of a house.

Draw, to a scale of $\frac{3}{4}$″ to a foot, showing a portion of the floor, with a $4\frac{1}{2}$″ × 3″ plate, 9″ × $2\frac{1}{2}$″ joist, and $1\frac{1}{2}$″ battens.

Add brick footings to the wall, standing on 12″ of concrete, the bottom of the concrete being 3′ below ground level. (13.)

9. Give a vertical section, $\frac{3}{4}$ full size, through a plumber's flange joint in an inch lead pipe passing through a $1\frac{1}{4}$″ floor board. (13.)

10. Draw a line diagram, to a scale of $\frac{1}{60}$, of an ordinary timber roof truss suitable for a 25-feet span, showing the purlins, poleplate, ridge-board, and common rafters, in their proper positions. (14.)

11. Draw, to a scale of $\frac{3}{4}$″ to a foot, both the front and back elevation of a $1\frac{1}{4}$″-ledged and braced battened door, 3′ × 6′ 6″.

Give a full-sized section through a joint between two of the battens, showing it ploughed and tongued, chamfered one face, and beaded on the other. (14.)

*12. Cross section of a stone to be formed into an ordinary window-sill.

Draw, to a scale $\frac{1}{4}$ full size, the finished section, weathered, throated, and grooved, and fixed in a 14″ brick wall. Two courses of brickwork to be shown below the sill, and two courses in elevation above the stool. (15.)

13. Draw, to a scale of 1″ to a foot, a vertical cross section through a fire opening on an upper floor, showing depth of opening 14″, back 9″, a brick trimmer arch, and a 9″ × 4″ trimmer, also front and back hearths. (15.)

*14. Line diagram of an iron roof truss.

Show, by sketches, the sections you would adopt for the different members, and give full details of the joint you would use at A and B. (16.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1897.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

NOTE.—*The diagrams connected with these questions will be found in fig.* 303.

*1. Plan of part of a brick wall at ground level, showing the footings and 9″ concrete foundations, the total depth below surface being 2′ 6″.

Draw, to a scale of 1″ to a foot, a section through *a—a*, showing the joints of the brickwork by single lines. (11.)

*2. The head of an oak gatepost and the end of a rail which is to be housed, mortised, and fox-wedged into it.

Draw to a scale of $\frac{3}{4}$″ to a foot, showing all the details of the joint before connecting up. The post to be shown in section. (11.)

3. Explain by sketches the meaning of the following terms :—

Joggle joint.
Spandrils of arches.
Lead plug.
Step flashing. (11.)

4. Draw, to a scale $\frac{1}{3}$ full size, a rolled iron joist 10″ × $4\frac{1}{2}$″, the web being $\frac{3}{8}$″, and the flanges averaging $\frac{3}{4}$″. (11.)

*5. A joint in a timber tiebeam.

Draw to a scale of an inch to a foot, making any addition or alteration you think necessary to ensure a secure joint, and give the name of the joint.

Draw a similar joint, capable of resisting both direct tension and compression. (12.)

*6. Plans of two courses of brickwork at the angle of a building built in English bond.

Draw to a scale of $\frac{3}{4}$″ to a foot, showing the joints by single lines, and marking by thicker lines those portions of the joints which run unbroken down the wall. (12.)

*7. Sections of the joists and boards of a common floor.

Draw, to a scale of $1\frac{1}{2}$″ to a foot, a cross section through three of the joists, showing the boards with a rebated and tongued heading joint.

Between one pair of joists show 2″ × $1\frac{1}{2}$″ herring-bone struts, and between the other pair sound boarding and pugging. (12.)

*8. Plan of a room which is to have a double floor.

Draw to a scale of $\frac{1}{60}$, showing by single lines the arrangement of the different members of the floor and writing their names against them.

Give a section, $\frac{1}{4}$ full size, through two of the floor battens, showing them laid with rebated and filleted joints. (13.)

9. Draw a horizontal section through the jamb of an external doorway in a store, showing a 14″ brick wall, with bull-nose dressings outside, 5″ × 4″ solid frame, rebated and beaded, and the hanging style of a $2\frac{1}{4}$″ framed and braced door, including two rebated and beaded battens of same. (13.)

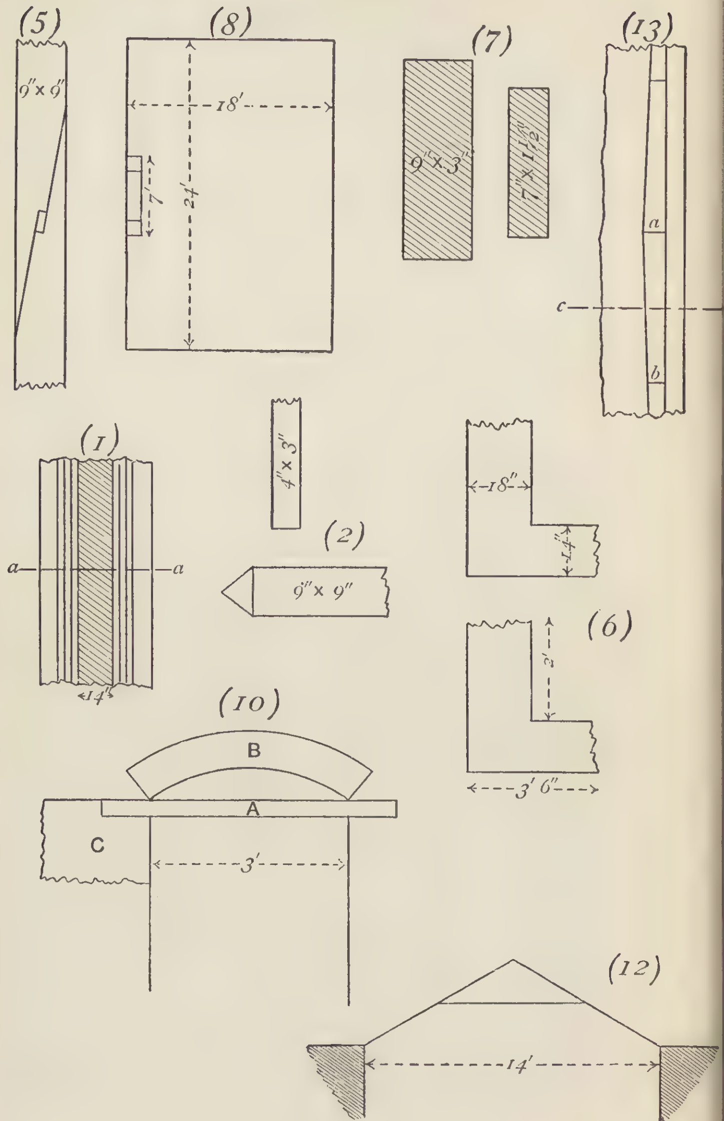


Fig. 303.

*10. Internal elevation of the head of a window opening in a stone building.

Draw to a scale of $\frac{1}{12}$, making any alteration you think necessary.

Give the names of the parts A and B, and at C show rough rubble built up to 20″ courses. (14.)

11. Draw an elevation of a six-panel door 7′ × 3′, writing their names on the different parts, and showing the difference between panels square and flat, bead butt, and bead flush, stating which is which. Also show by dotted lines how the parts are framed together. (14.)

*12. Line diagram of a timber roof with a rise of $\frac{1}{3}$ the span, the rafters being $3\frac{1}{2}$″ × $2\frac{1}{2}$″, and the collars $4\frac{1}{2}$″ × $2\frac{1}{2}$″.

Draw, to a scale of $\frac{1}{2}$″ to a foot, a little more than half of same, showing how it would rest with over-hanging eaves on a 9″ brick wall.

The joint between the collar and the rafter is to be shown in detail, and must be made so as not to weaken the rafter.

Give the name by which the roof is known. (15.)

*13. Plan of part of a lead roof gutter behind a brick parapet, showing the position of the joints in the lead.

Draw, to a scale $\frac{1}{4}$ full size, cross sections through *a* and *b*, giving full details of the joints. Also draw a section through *c—c*, including three courses of countess slates on 1″ boards. (15.)

14. Draw, to a scale of $\frac{1}{48}$, an elevation of a little more than half of an iron roof truss for a 30′ span, the rise being $\frac{1}{4}$ the span, from the following data:—

Principal tea-iron rafters 4″ × 3″ × $\frac{3}{8}$″; three vertical rods of $\frac{3}{4}$″ and $\frac{1}{2}$″ metal; four inclined angle iron struts, 2″ × 2″ × $\frac{3}{8}$″ and $2\frac{1}{4}$″ × $2\frac{1}{4}$″ × $\frac{3}{8}$″.

Tie rod 1″ diameter, with a 9″ camber. (16.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1898.

Instructions.

You are permitted to answer only *seven* questions.

Note.—*The diagrams connected with these questions will be found in fig.* 304.

*1. The figure shows a wrong way of laying bricks in English bond at the end of a 14″ wall.

Draw, to the scale of $1\frac{1}{2}$″ to a foot, showing how the bricks ought to be laid, and mark the joints in the course below by dotted lines. (11.)

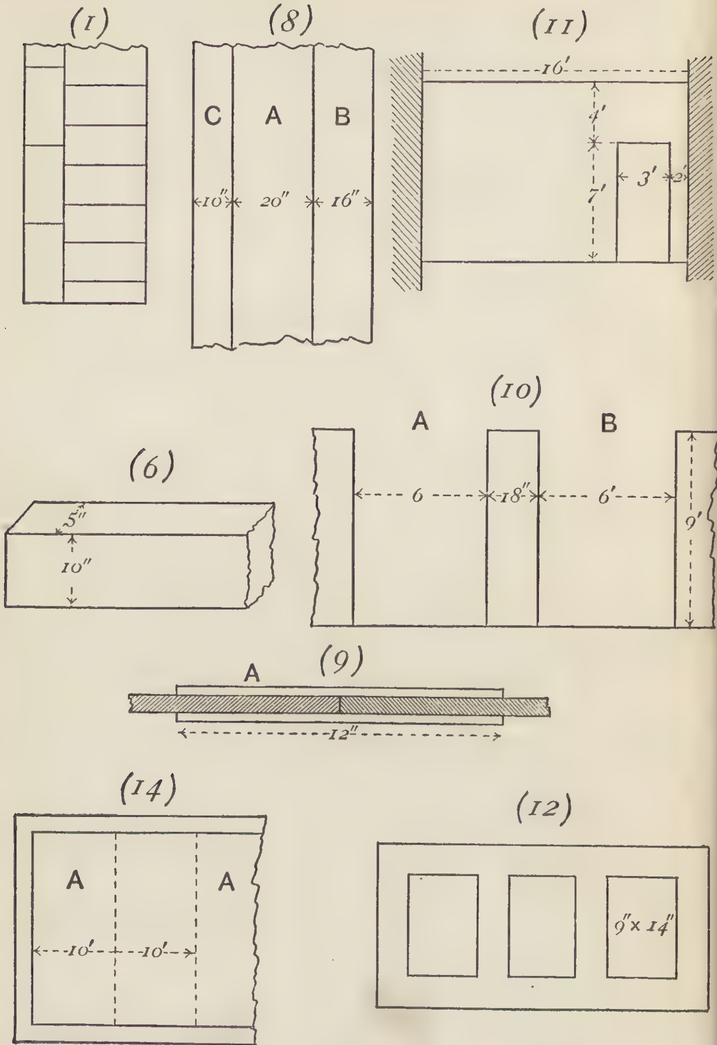
2. A door opening in a 9″ internal wall of a brick building is 3′ 3″ wide.

Draw, to a scale of $\frac{1}{12}$, an elevation of the head of the opening, showing a 9″ × 3″ wood lintel and a common arch in two rings. (11.)

3. Give a vertical section, $\frac{1}{3}$ full size, through the foot of a 6″ × 6″ wooden doorpost, fitted with a cast-iron shoe 4″ deep, of $\frac{3}{16}$″ metal, securely leaded down to a stone step. (11.)

4. Give, to a scale of $\frac{3}{4}$″ to a foot, a front elevation of an external framed and braced door, 3′ 3″ × 7′. Show 6″ margins, $4\frac{1}{2}$″ battens, and indicate the unseen members of the framing by dotted lines. (11.)

5. Give explanatory drawings, $\frac{1}{3}$ full size, in isometric projection or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A
10'
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(12)
9" x 14"

FIG. 304.

otherwise, showing an ordinary scarfed joint in a $4\frac{1}{2}'' \times 3''$ wall plate; also a dove-tailed angle joint for same.

Do you consider the latter a good joint; if not, say why? (12.)

*6. One end of the tie-beam of a timber roof truss.

Draw, to a scale of $\frac{1}{6}$, adding the foot of the principal rafter, $5'' \times 4''$, framed to the tie-beam, and secured by a stirrup-iron 2″ wide, with a connecting plate. (12.)

7. Give explanatory sketches, showing—

The difference between a "bossed-up" and a "dog-ear" joint in leadwork.

A torus moulded skirting.

A cocked bead and fillet. (12.)

*8. Elevation of part of a 16″ stone enclosure wall.

Draw, to a scale of $\frac{1}{18}$, showing at *A* random rubble, at *B* coursed rubble, and at *C* a saddle-back stone coping with a 3″ roll.

Give a section of the coping. (13.)

*9. Longitudinal section of a riveted joint in an iron tie-bar, 9′ wide.

Draw, to a scale of $\frac{1}{4}$, a plan of the joint, showing nine $\frac{3}{4}''$ rivet holes, on the side *A*, arranged as chain riveting; and eight on the other side, arranged as zigzag riveting. (13.)

*10. Part elevation of two adjoining openings in a brick building with stone dressings.

Draw, to a scale of 3′ to an inch, adding a stone plinth 16″ high, weathered at top—an equilateral pointed arch over *A*—and a segmental arch of 120° over *B*.

Show stone voussoirs to both arches, 9″ deep, springing from stone imposts. (14.)

*11. Elevation of a common trussed partition carried on a brick wall below.

Draw half of same, to a scale of $\frac{1}{24}$, filling in the details, including the doorway.

The scantlings used to be $4\frac{1}{2}'' \times 3''$ and $4\frac{1}{2}'' \times 2''$, and the different members to be figured and named. (15.)

*12. Horizontal section through a brick chimney shaft.

Draw, to a scale of $\frac{3}{4}''$ to a foot, the end elevation of the top of the shaft down to two courses below the necking, which is to be three courses in depth, two plain and one weathered. Above the necking show eight plain courses; and then the cap, consisting of three sailing courses, four plain courses, and three splayed.

Mark in the horizontal joints of the brickwork throughout, and add the vertical joints also below the sailing courses. (15.)

13. Draw, to a scale of 3 ft. to an inch, a section of at least half of a timber roof over a 34-ft. span, with a pitch of 30°, carried on 14″ brick walls, showing a truss in elevation, and taking the following details:—

Tie-beam, $5'' \times 10''$; Principals, $5'' \times 5''$; Queens, $5'' \times 3''$; Straining beam, $5'' \times 7''$; Straining sill, $5'' \times 3''$; Purlins, $8'' \times 5''$; Rafters, $4'' \times 2''$; Ridge piece, $9'' \times 2''$; 1″ slate boarding.

Show all necessary ironwork to roof truss. (15.)

*14. Plan of part of a double floor showing positions of girders by dotted lines.

Draw, to a scale of $\frac{3}{4}''$ to a foot, a section through *AA*, showing rolled iron girders $10'' \times 5''$, bridging joists $9'' \times 2\frac{1}{2}''$, floor battens $7'' \times 1\frac{1}{2}''$, and ceiling joists $5'' \times 2''$.

The depth of the floor to be kept down as much as possible. (15.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1899.

INSTRUCTIONS.

You are permitted to answer only *seven* questions.

NOTE.—*The diagrams connected with these questions will be found in fig.* 305.

1. Draw, $\frac{1}{4}$ full size, a cross section through a saddle-back stone coping 12″ × 5″, throated and carrying an iron railing.
   The section to be through the foot of a cast-iron standard 2″ diameter, showing it securely leaded to the coping. (11.)

*2. The feet of two timber posts framed into a sill piece.
   Draw, to a scale of an inch to a foot, a section through *a—a* showing the details of a mortised joint, and through *b—b* showing a bridle joint. (11.)

3. Explain, by means of sketches, the meaning of the following terms :—
   Wood bressummer.
   Tabled joint.
   Pugging.
   Trimmer arch. (11.)

*4. Elevation of a portion of a stone wall.
   Draw, to a scale of 2′ to an inch, showing at *A* uncoursed squared, or snecked, rubble; and at *B*, squared rubble laid as coursed header work.
   At *C* show plain block and start ashlar quoins. (11.)

5. Draw, to a scale of $\frac{3}{4}$″ to a foot, a cross section of a trench 2′ 9″ deep, for the foundations of a building, showing 9″ of concrete carrying the footings of an 18″ brick wall built in English bond.
   Fill in the joints of the brickwork up to the ground level. (12.)

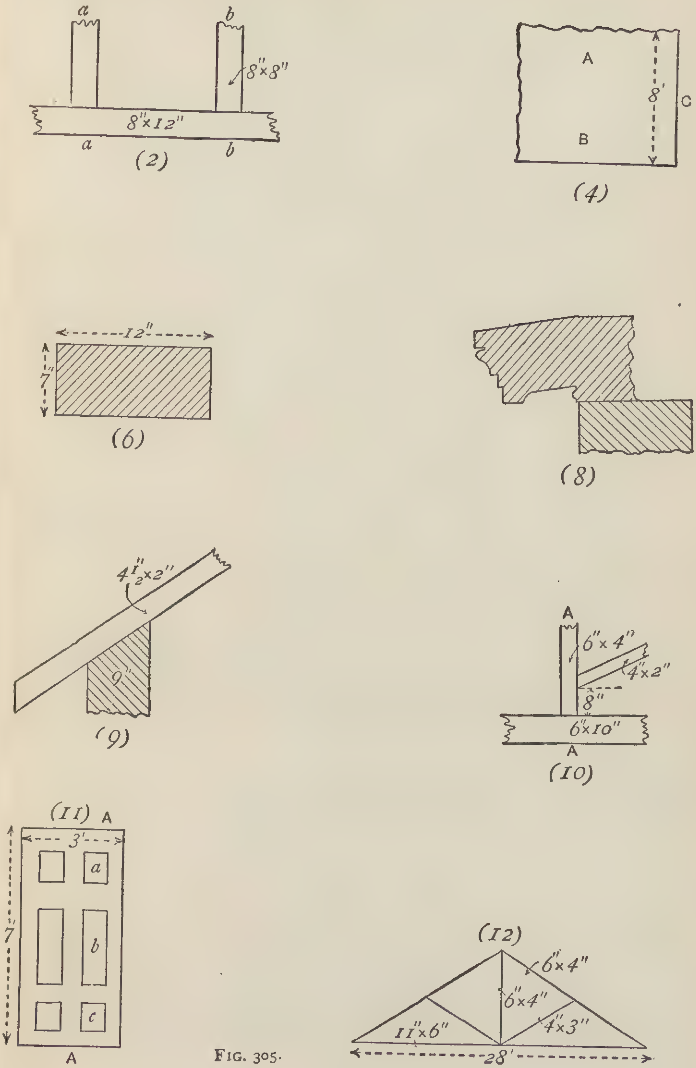
*6. Section of a wooden floor binder.
   Draw to a scale of $\frac{1}{8}$, adding a 6″ × 3″ bridging joist cogged to the binder, and a 4″ × 2″ ceiling joist tenoned to the same, and carrying a lath and plaster ceiling.
   Show the joints in section. (12.)

7. A cast-iron girder 15″ × 8″, and supported at both ends, has flanges of 12 and 4 square inches respectively.
   Draw, $\frac{1}{4}$ full size, a cross section of the girder.
   State why one flange is larger than the other. (12.)

*8. Section of a stone cornice on an 18″ wall built of coursed rubble.
   Draw, to twice the scale, adding a saddled joint in elevation, and a blocking course 18″ high.
   Give a cross section through the saddle joint, and state its object. (13.)

*9. Part of the eaves of a roof over a brick building.
   Draw, to a scale of an inch to a foot, adding a $4\frac{1}{2}$″ × 3″ wall plate, a 7″ × 1″ fascia board, a 5″ ogee gutter, and 4 courses of slates laid to a 3″ lap and centre nailed to $\frac{3}{4}$″ boards. Give the sizes and names of the slates shown. (13.)

*10. Elevation of the foot of a queen post in a timber roof truss.
   Draw correctly, to a scale of an inch to a foot, adding a stirrup iron $2\frac{1}{4}$″ × $\frac{3}{8}$″, with gib and cotter adjustment.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7'
b
c
A
(12)
6"×4"
6"×4"
4"×3"
11"×6"
28'

FIG. 305.

Draw a vertical section through *A—A*, showing all the details of the iron and wood work, before tightening up, including the framing of the queen post to tie-beam. (14.)

*11. Elevation of a 2″, 6-panel, door, with 5″ and 10″ rails.

Draw, to a scale of $\frac{1}{12}$, a vertical cross section through *A—A*, making any alteration you think advisable, and showing the following details :—

At *a* a solid panel, bead flush on front, and bead butt at back.

At *b* a moulded and flat panel, chamfered at back.

At *c* a raised and moulded panel, square and flat at back. (15.)

*12. A line diagram of a timber roof truss, showing the scantlings of the different members.

Draw, to a scale of $\frac{1}{30}$, at least half of the truss, showing it resting on a $4\frac{1}{2}'' \times 3''$ wall plate and a 14″ brick wall.

Add a $4'' \times 2''$ common rafter properly supported.

Give the name of the truss, and of all the different timbers shown. (15.)

13. Draw a horizontal section, half full size, through one side of a window frame for double hung $1\frac{3}{4}''$ moulded sashes. The section to include one style of the lower sash, showing how the glass is fixed, and the following details :—

$\frac{5}{8}''$ inside and outside linings.
$1\frac{1}{4}''$ pulley piece.
$\frac{3}{8}''$ back lining.
$\frac{3}{8}''$ parting bead.
$1'' \times \frac{5}{8}''$ inside bead.
$\frac{1}{4}''$ parting slip. (15.)

14. Give line diagrams, to a scale of 6 ft. to an inch, of the following forms of iron roof trusses :—

(*a*) For a common trussed rafter roof, 24 ft. span.

(*b*) For a queen rod roof truss over a 36 ft. span.

In each case the rise to be $\frac{1}{5}$ span, and the camber of tie-rod $\frac{1}{30}$ span.

In case (*b*) give an elevation, $\frac{1}{4}$ full size, of the joint at the foot of the king rod, which is to pass through the tie-rod with a screw-nut adjustment ; the different members being of $1\frac{1}{4}''$ and 1″ round iron, and tee iron $2\frac{1}{2}'' \times 2'' \times \frac{3}{8}''$. (15.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1900.

Instructions.

You are permitted to answer only *seven* questions.

Note.—*The diagrams connected with these questions will be found in fig.* 306.

1. Briefly define ordinary English brick bond.

Draw, to a scale of $\frac{3}{4}''$ to a foot, a plan showing the arrangement of the bricks in a $2\frac{1}{2}$ brick wall built in English bond, the bricks in the course below being indicated by dotted lines. (11.)

*2. Section of part of a common floor, showing $9'' \times 3''$ joists, and $1\frac{1}{4}''$ boarding with a heading joint.
Draw, to a scale of $\frac{1}{6}$, making any alteration you think necessary, and adding pugging and a lath-and-plaster ceiling.
State the object of pugging, and give the name of the heading joint. (11.)

*3. Interior elevation of a $7' \times 3'$ door.
Draw, to a scale of $\frac{3}{4}''$ to a foot, making any alteration you think necessary.
Write against the door its name, and the names of all its different members. The joints need not be shown. (11.)

4. Draw one-half full size a section of an ordinary $2''$ lead roll, and of a hollow roll, as used for lead flats. (11.)

*5. Plans of two successive courses of brickwork at the junction of a party wall with the main wall of a building, the latter being built in single Flemish bond.
Draw, to a scale of $\frac{3}{4}''$ to a foot, showing the joints of the brick-work. (12.)

6. Give sketches explanatory of the following terms :—
Flitch girder.
Tusk tenon.
Squint quoin.
Transom. (12.)

*7. Sections showing the different members of a cast-iron cantilever.
Draw the section of the cantilever, $\frac{1}{3}$ full size. (12.)

8. Show clearly by sketches the difference between a double floor with rebated and filleted battens, and a framed floor with ploughed and tongued boards. (14.)

*9. Horizontal section through part of a brick boundary wall built in English bond.
Draw, to a scale of $1\frac{1}{2}''$ to a foot, showing the joints of the bricks in English bond in two courses, the lower one by dotted lines ; also an elevation of the face *A*, showing the four top courses of the wall, finished with a stone saddle-back coping $6''$ deep, $3''$ wider than the wall, and weathered down $3''$.
Add a cross section of the coping over the $14''$ brickwork, showing it properly treated so as to throw rain clear of the face of the wall. (14.)

*10. Section of part of a small span roof.
Draw, to a scale of $1''$ to a foot, adding Countess slates with $4''$ lap, centre nailed on $2'' \times \frac{3}{4}''$ battens, a $3\frac{1}{2}''$ half-round eaves gutter, and a $1''$ beaded fascia board. The rafter to project $9''$ from face of wall. Pitch of roof $30°$.
Make any other addition or alteration you think necessary. Name the different parts. (14.)

*11. Line diagram of an ordinary timber truss for a $24'$ span.
Draw at least half the truss, to a scale of $\frac{1}{24}$, making any addition you think necessary.
Give the name of the truss, and enlarged drawings, to a scale of $1\frac{1}{2}''$ to a foot, of the joints at the head and foot of the principal rafter. (14.)

12. Draw, to a scale of $1\frac{1}{2}''$ to a foot, the plan and central cross section of an $11'' \times 6''$ stone window sill for a $3'\ 6''$ opening. The sill to be

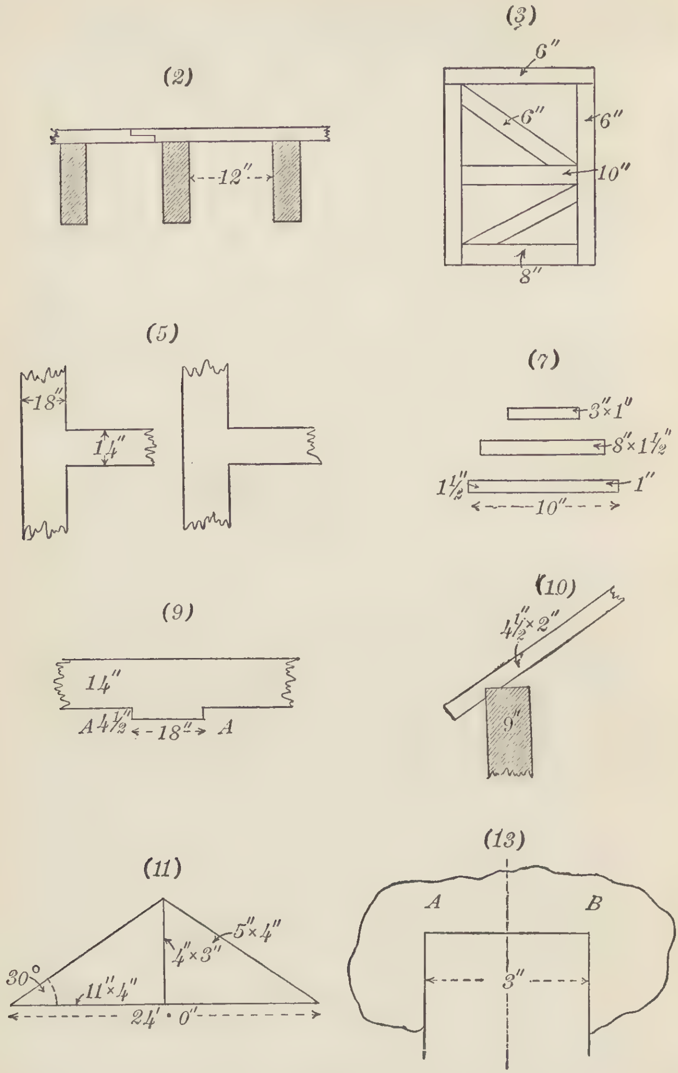
(2)
12″
(3)
6″
6″
6″
10″
8″
(5)
18″
14″
(7)
3″×1″
8″×1½″
1½″
1″
10″
(9)
14″
A 4½
18″
A
(10)
4½″×2″
9″
(11)
30°
11″×4″
4″×3″
5″×4″
24′ · 0″
(13)
A
B
3″

FIG. 306.

weathered, throated, and grooved, and to project 2½″ from a 14′ brick wall.

At right end of plan, show the course of brickwork, in English bond, immediately above the sill, with a 4½″ reveal; and at left end the brickwork upon which the sill rests. (14.)

*13 External elevation of a window head in a 14″ brick wall, finished externally with a 14″ gauged camber arch, and internally with a 9″ × 3″ wood lintel and common arch.

Draw, to a scale of 1½″ to a foot, showing at *A* the details of the external elevation, and at *B* the internal elevation, the brickwork being in single Flemish bond. (15.)

14. Draw, to a scale of $\frac{1}{24}$, a little more than half of an iron king rod roof over a 28′ span. Rise ¼ span. Show—

Principal rafters and struts, of tee iron.
King and tie rods, of round iron.
Common rafters and their supports, of wood.

The scantlings and joints can be assumed. (15.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1901.

Instructions.

You are permitted to answer only *seven* questions.

Note.—*The diagrams connected with these questions will be found in fig.* 307.

1. Why is a brick made so that its breadth is less than half its length? Can you explain any advantage in "perforating" bricks? What are gauged arches? (12.)
2. Draw, to the scale of $\frac{1}{16}$, the plans of two courses of a brick pillar in English bond, the pillar to be square in section, four bricks in the side. To what height could you *safely* build a pillar of this section, assuming the safe load on a course of bricks to be 8 tons per square foot, and taking the weight of a cubic foot of brickwork at 120 lbs.,—neglecting wind pressure? (12.)
3. What are—a skew arch; a skewback; a pillar; an abutment; a column; weathering of a window sill; weathering of stone; voussoirs; chamfer; plinth? (12.)

*4. A rubble wall with half-round concrete coping: draw it to the scale of $\frac{1}{16}$, showing the stones and mortar. (12.)

5. Show three soakers with cover flashing in position against a brick wall,—slates 24″ long. Show clearly to the scale of ¼ all details, with such drawings and sketches, accompanied by explanations and dimensions, as you think sufficient. (12.)
6. Draw or sketch, to the scale of ¼—
   (1) A tenon and housed joint, mortised piece 4″ × 4″, tenoned piece 3″ × 4″.
   (2) A tusk-tenoned joint, 9″ × 3″ timbers.
   (3) A dovetailed notch, timbers 4½″ × 3″. (12.)
7. Draw or sketch, to the scale of ⅛, the top and bottom of a king post, showing attachments of principal rafters and of the struts and tie-

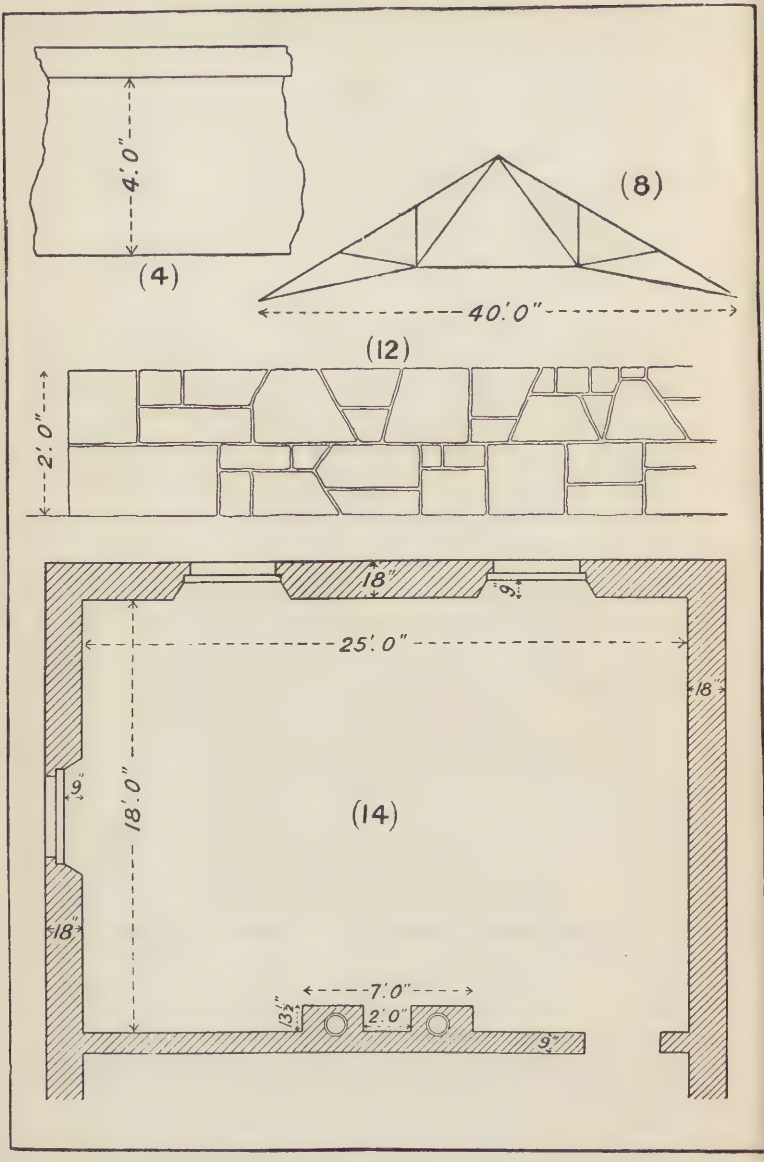

FIG. 307.

beam, and showing ironwork—rafters 8″ × 4″, shank of king post 6″ × 4″, struts 4″ × 4″, tie-beam 12″ × 4″. (12.)

*8. A skeleton drawing of an iron roof truss. The rafters are formed of L irons. Draw, to the scale of $\frac{1}{2}$, the joint at the apex. Repeat the diagram on your paper, and putting reference numbers to the different members, sketch cross sections of them. (14.)

9. Draw or sketch, to the scale of $\frac{1}{4}$, a cross section showing bottom rail of sash, wood sill of window frame, stone sill, and window back; showing elbow. The window back is 2′ high, and the wall of the recess is 10″ thick. (14.)

10. Draw or sketch, to the scale of $\frac{1}{8}$, cross section of eave extending 4′ up the roof, showing slates resting over a cut stone eave course: the wall is 18″ thick, rafters 5″ deep, without roof trusses—ceiling joists at wall plates; slates 20″ long. Explain fully. (14.)

11. Draw, to the scale of $\frac{1}{16}$, the inside elevation of a ledged and braced door and door frame; the door is 7′ × 3′. Show hinges, latch, stock lock; sketch cross section showing jambs (wall $1\frac{1}{2}$ bricks thick). (14.)

*12. Two courses of masonry: how would you describe it? Sketch these two courses on your paper, and put reference numbers on the stones of the top course showing the order in which you think a mason would set them, giving reasons. (14.)

13. Draw, to the scale of $\frac{1}{8}$, elevation of a double casement or French window 6′ × 3′ 6″: draw cross section of bottom bar of window and sill of frame; sketch hinges and fastening bolt. What is this kind of bolt called? (15.)

*14. A floor, of fir timber, joists lathed and plastered below to form ceiling of lower room. Draw plan, to the scale of $\frac{1}{48}$, showing by single lines complete joisting, figure scantlings. Draw, to the scale of $\frac{1}{8}$, cross section through hearth reaching above camber-bar of fireplace. Show details of bearing of joists and of trimmer. (15.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1902.

Instructions.

You are permitted to answer only *seven* questions.

Note.—*The diagrams connected with these questions will be found in fig.* 308.

*1. Sketch this tool upon your paper, showing the pick better placed, and explain why you alter it. For what is this tool used? (12.)

2. What are—Reveals, Jambs, Collar braces (Collar beams), Battens, Studs, Deals, Planks, Perpends, Screeds, King-closer? (12.)

*3. The figure shows in skeleton a bracket used by builders for pointing brickwork or for outside plastering: sketch the bracket so that an exact drawing could be made from your sketch (marking dimensions). Show clearly how its parts are connected (the parts being of red deal): show how it is supported when hung against a wall. (12.)

*4. What is the name of the bracket of the previous question? If we assume that it carries a uniformly distributed load of 8 cwt. on *AB*, so that we may imagine a downward force of 4 cwt. at *A*, what kind of stress is in *AC*, and what is its amount? (12.)

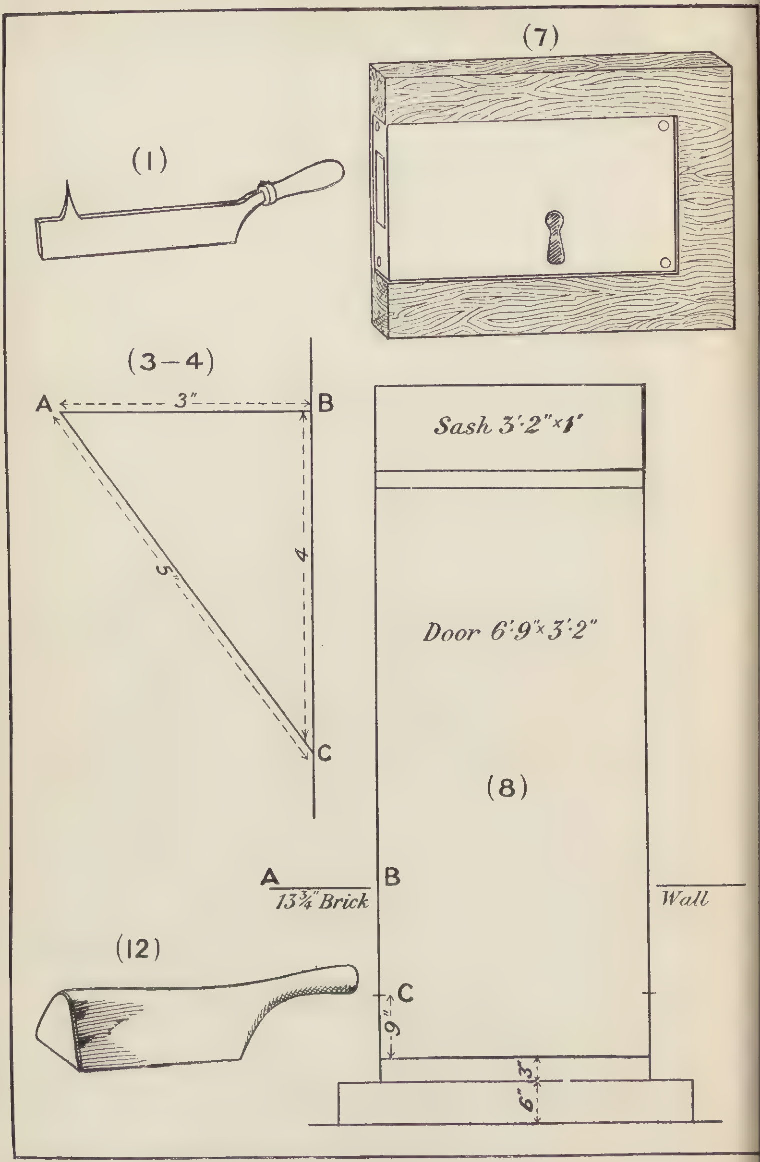

Fig. 308.

5. Given sand, lime, and hair, as delivered at the building, describe in detail how you would prepare "*coarse stuff*" for plastering: you are not supposed to have a mortar mill. (12.)
6. Sketch neatly, to the scale of about $\frac{1}{6}$, a slate of the dimensions 24″ × 12″ dressed and holed: the lap is 4″. What are the dimensions of the "weather" (or margin) of this slate? What is the distance from the hole to the tail? (12.)
*7. What is the name of the lock shown? Describe how you would fix it to a door. Explain and illustrate by sketches the mechanism of a common single tumbler lock. What are the "*wards*"? (12.)
*8. The sketch shows a door frame for an outside door: it is set upon door-blocks, and the brick walls are being built to it.

   Draw carefully, to the scale of $\frac{1}{12}$, an elevation of the door frame, step, sill, and brickwork (showing the joints by double lines to the left of the door for, say, three bricks from the door): show temporary bracing: describe how you would stay the door frame temporarily. Draw, to the scale of $\frac{1}{4}$, cross section of frame at *AB*, showing the plan of top course of brickwork, and a short piece of vertical section at *C*, showing the connection with the door block. (14.)
9. Sketch, to the scale of $\frac{1}{12}$, a sample of snecked rubble masonry face (say about 4′ × 4′). Show the mortar joints with double lines.

   Sketch also the top of the sample, as a plan, showing how you bond the wall across. (14.)
10. A brick wall, 21′ high (measured from the soil on which it rests), $13\frac{3}{4}$″ thick, carries a load of 1 ton per foot run on its top. Say what is the approximate weight of a cubic foot of brickwork. Draw, to the scale of $\frac{1}{24}$, a cross section of the footings on the assumption that the soil is not to be stressed to a greater amount than 1 ton per square foot. (14.)
11. Describe exactly the laying of batten-width tongued and grooved common Baltic flooring: how would you manage when the floor has been finished so far that there is no longer room for the cramps between the wall and finished floor? Sketch the usual flooring nail. What is it called? Where do you drive the nails? Sketch a cross-section of a heading joint. (14.)
*12. For what purpose is this tool used? You have to cover a right circular cone with 6-lb. lead. The cone is 3′ in diameter at the base, and it is 2′ high. Assuming that the joints are butted, what is the weight of the lead? Such a cover being made, if a straight cut is made from the apex to the circumference of the base, the cover may be made to lie flat; draw to the scale of $\frac{1}{12}$ its outline when thus flattened. (14.)
13. What is bond in brickwork? When you say that a certain wall is built in Flemish bond, to what do you refer? You have to build a $1\frac{1}{2}$-brick wall, showing Flemish bond in *one face*—the appearance of the other face is of no consequence, as it is to be plastered. *No bats are allowed.* Sketch the plan of a course, say 5 bricks long, in full lines, and show the joints of the course below in dotted lines. (15.)
14. Describe carefully the work of laying a kitchen floor with 6″ × 6″ tiles, $\frac{1}{2}$″ thick, in two colours. The floor is 14′ × 13′: how many tiles ought to be *ordered* for the work? (15.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1903.

INSTRUCTIONS.

You are permitted to answer only *seven* questions.

NOTE.—*The diagrams connected with these questions will be found in fig.* 309.

*1. For what work is this tool used? Describe how the workman holds it when he uses it for ordinary work. (12.)

2. What are :—meeting-rail, muntin, tread, riser, going, lacing course, quirked ogee, coarse stuff, gauged stuff, droved work, rusticated? (Full marks will be given for *nine* correct definitions.) (12.)

*3. In a certain town electric wires are borne on brackets, like that shown: given the weight at A as being 40 lbs., assuming that this pressure may be transferred to the point B where the bracket bears against the slate, as shown, and assuming that the directions of the reaction and of the third force are as shown, what is the amount of the reaction in lbs.? (15.)

*4. Make a tracing, in ink, of this drawing and of the writing and figures. (The Indian ink should be sufficiently thick to give opaque lines, suitable for photographic printing; the lines should be well defined, uniform in breadth, having firm unbroken edges; and they should neither stop short of nor go beyond the proper points.) (15.)

5. Sketch (approximately), to the scale of $\frac{1}{2}$, a good strong thumb-latch for a door; also the keeper, or catch, to be fastened to the door-frame. Describe what you consider to be important points in a good latch, such as you sketch. (12.)

6. (*a.*) What is a bib-cock? (*b.*) Describe how a "wiped-joint" is made. (12.)

7. A rectangular rain-water tank weighs 300 lbs.; it is $6' \times 4'$, and it is $2'\ 8''$ deep (internal dimensions): it is supported with its bottom horizontal. Owing to a stoppage of the overflow pipe, it is filled with water. (*a.*) What is the pressure of the water per square foot on the bottom of the tank? (*b.*) What is the weight of the tank and water? (*c.*) How many gallons of water does the tank contain? (14.)

8. The slates on a roof are $24'' \times 12''$; an average slate weighs 7 lbs.; the slates are laid with a lap of $4''$. What is the weight of slates which cover an average square of roof?

9. Draw, to the scale of $\frac{1}{12}$, the elevation of a casement window (not a *pivoted* sash) $4' \times 2'\ 6''$ (sash size); a single sash in 4 panes; show reveals and stone sill; sketch, approximately to the scale of $\frac{1}{4}$, the essential details of the hinges and fastener. (14.)

10. Sketch, to the scale of $\frac{1}{12}$, the face (elevation) of a completed course of rubble masonry (the course being, say, $15''$ deep); sketch on top of this completed course portions of a second course in process of building; explain why the stones shown—of the second course—are placed where you sketch them. How does the mason keep his work truly in line? How does he use his plumb-rule in rock-faced work? (14.)

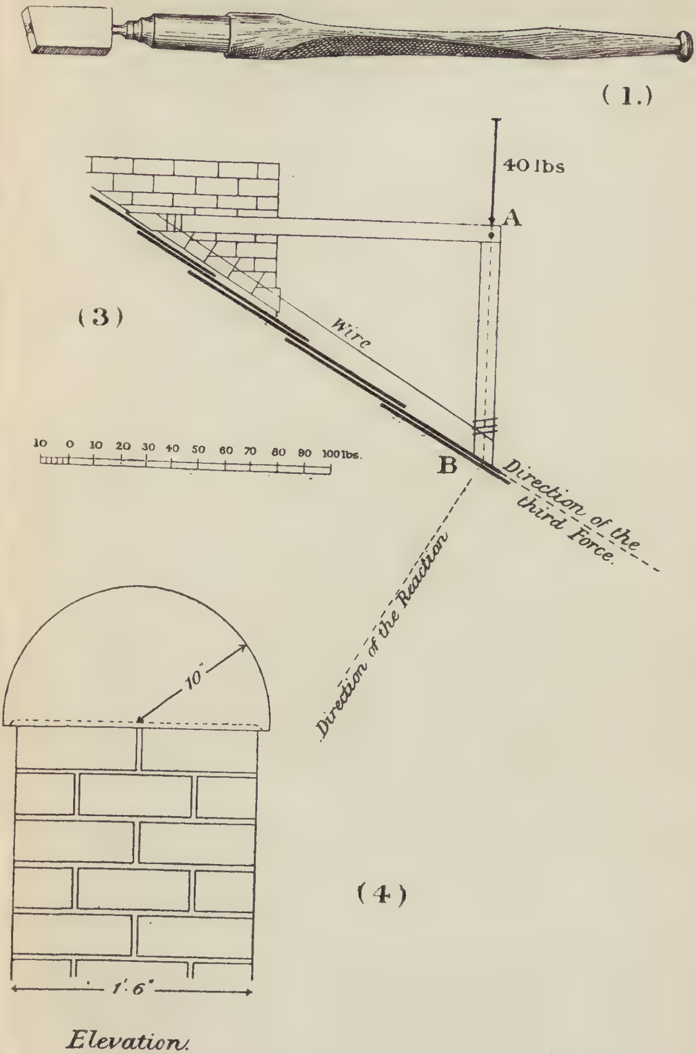
(1.)
40 lbs
A
Wire
(3)
10 0 10 20 30 40 50 60 70 80 90 100 lbs.
B
Direction of the third Force.
Direction of the Reaction
10"
1' 6"
(4)
Elevation.

Fig. 309.

11. A plasterer is laying on the first coat of coarse stuff on lathed work, and you see him driving the trowel at right angles to the direction of the laths. This is wrong. Can you explain why it is wrong? (12.)

12. Sketch, to the scale of $\frac{1}{8}$ (approximately), a fireplace—grate, oven, and boiler—suitable for the kitchen or living-room of an artisan's cottage: explain the setting and flues. (14.)

13. Describe how you would prepare (from materials in the usual commercial conditions) a pot of light-coloured paint for fourth coating, inside work; give a name to the shade of colour you produce. (12.)

14. Draw plans of two successive courses of a half-brick-built chimney-stack of three flues (scale $\frac{1}{12}$); show mortar joints as double lines; show pargetting. (12.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1904.

Instructions.

You are permitted to answer only *seven* questions.

Note.—*The diagrams connected with these questions will be found in fig.* 310.

*1. What workman uses this tool? Can you give a reason for the grooving of the hammer face *a*? What purpose is served by the slot *b*? Why is the head of this hammer attached to the handle by cheeks *d*, not by a hole in the head? (12.)

2. What are—Faucit, stopped bead, bolection moulding, banker, tuck pointing, rusticated, priming, joggle, going (of stairs), lintel, sectional elevation, architrave? Nine correct definitions will get full marks. (12.)

*3. The skeleton drawing shows two rafters tied at the feet by a ceiling joist: copy it upon your drawing paper. Assuming that the joint at *A* is held by a smooth pin which is at right angles to the paper, find the stresses produced by the applied force, making use of the triangle of forces, and write the amount of the resulting stress in each rafter in cwts. and tenths, along the line of the drawing corresponding to the particular rafter. (15.)

4. Answer either (*a*) or (*b*), not both—
   - (*a*) A workman is dressing roofing-slates. Describe how he divides a slate into two parts. (12.)
   - (*b*) Sketch on your squared paper a straight line extending over 12 spaces: this line represents the edge of a roofing-slate which is 24″ long: the lap being 4″, mark on the line the position of the hole, and dimension its distances from the head and from the tail of the slate (the slate is not to be "nailed at the head"). (12.)

5. Answer either (*a*) or (*b*), not both—
   - (*a*) Assume the distance between two lines of your squared paper to represent 1″. Sketch upon it a tower bolt fastening attached to a door and door-post: it should be such a bolt as may be secured by a padlock. (12.)
   - (*b*) To the same scale as for *a*, sketch on the squared paper a

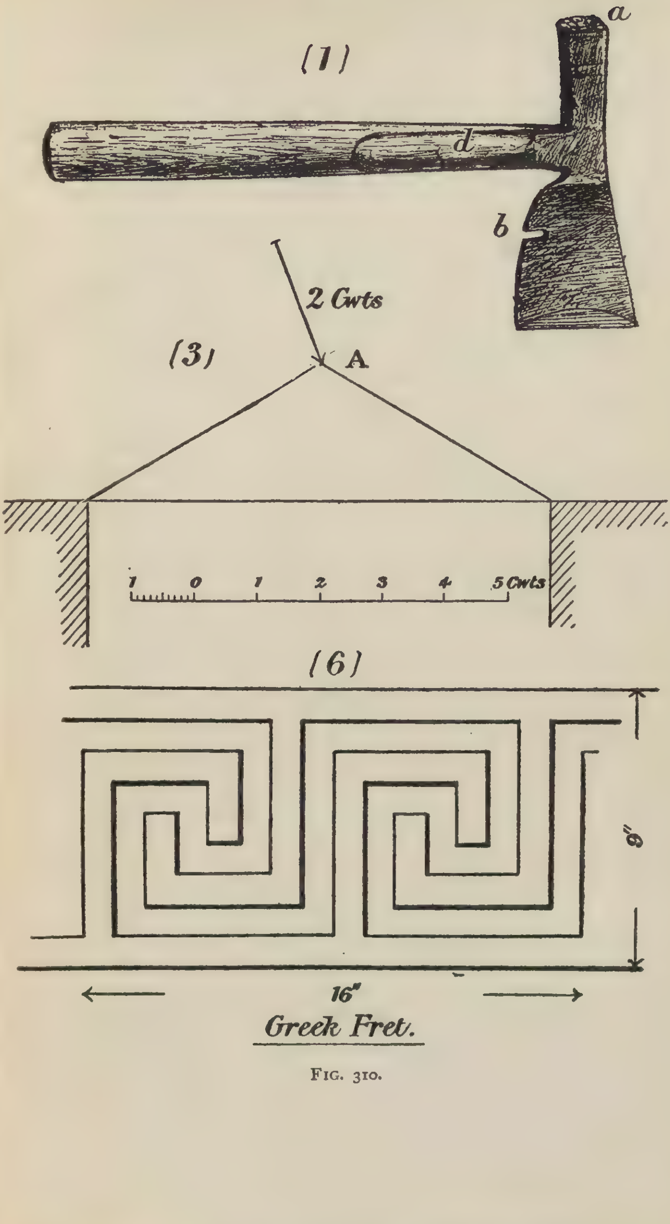

FIG. 310.

hook-and-eye hinge for a stable-door which opens outwards and lies flat against the wall when fully turned to it: the door-post is 4″ × 3″, the reveal is 6″ deep. (12.)

*6. Make a tracing, in ink, of this ornament; trace also the writing and dimensions. (The Indian ink should be sufficiently thick to give opaque lines suitable for photographic printing, the lines should be well defined, each line uniform in breadth, having firm, unbroken edges; and they should neither stop short of nor be carried beyond the proper points.) (14.)

7. Common window glass is specified as of 15 oz., 21 oz., etc. What do these weights refer to? What is this kind of glass called? (12.)

8. What is a rod of brickwork? Sketch on your squared paper (assuming the distance between two lines to represent 3″) a top angle of a window opening, showing, say, 3 courses of bricks down the reveal, and about the same distance along the soffit, and extending 3 or 4 bricks' length horizontally from the reveal, and the same distance upwards from the soffit. What do you call the bond which you show in the general facing? (15.)

9. Answer either (*a*) or (*b*), not both—

(*a*) Assuming the gauge of your squared paper to represent 1″, sketch a side view of a ball valve for a water cistern. Show by sketches (enlarged, if you think necessary) section of valve from which may be seen how the rising and falling of the ball shuts and opens the valve. (12.)

(*b*) Assuming the gauge of your squared paper to represent ½″, sketch a section showing clearly a union connexion of a brass ferrule to a 1″ lead pipe. (12.)

10. Draw to the scale of ½ a cross section of the pulley style and casing of a superior sash frame, 2″ sashes: show the joints clearly; mark on the parts the end grain of the wood; show the weights and parting slip, back lining, etc., complete. How do you fix the guard beads (window slips)? What advantage is claimed for forming a shallow rabbit (rebate) on the pulley styles to form a seat for the guard beads? (14.)

11. Describe how you would: (*a*) divide a block of Bath stone into two useful pieces; (*b*) divide a block of granite into two useful pieces.
Sketch on your squared paper the tools used in each case. (14.)

12. Describe fully the operations of opening a flagged yard; sinking a trench; laying 9″ glazed stoneware spigot and socket pipes jointed with Portland cement mortar; refilling the trench and reinstating the flagged yard (the ground is easy ground, no timbering is required). (14.)

13. Under what circumstances would you put inverted arches in walls just over the foundations: and in what circumstances would you use arches not inverted in the foundations of a building? (14.)

14. Sketch on your squared paper (assuming the lines to represent 1′ apart) the elevation of a pair of collar-braced (collar beam) rafters: walls 14′ apart. Show wall-plates and portions of the walls in section. Sketch to a larger scale (take the lines on the paper as being to 3″ gauge) portion of the top of one wall and wall-plate in section: showing rafter foot, and showing the eavesgutter in section. (14.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1905.

INSTRUCTIONS.

You must not attempt more than *seven* questions in all, and of these No. 1 must be one ; that is to say, you are allowed to take not more than six questions in addition to No. 1.

NOTE.—*The diagrams connected with these questions will be found in fig.* 311.

*1. Make a neat tracing in ink of the drawing given, with the writing and figures : the lines should be firm and solid, and should finish exactly at the proper points. (15.)

2. What are the essential qualities to be looked for in good sand, lime

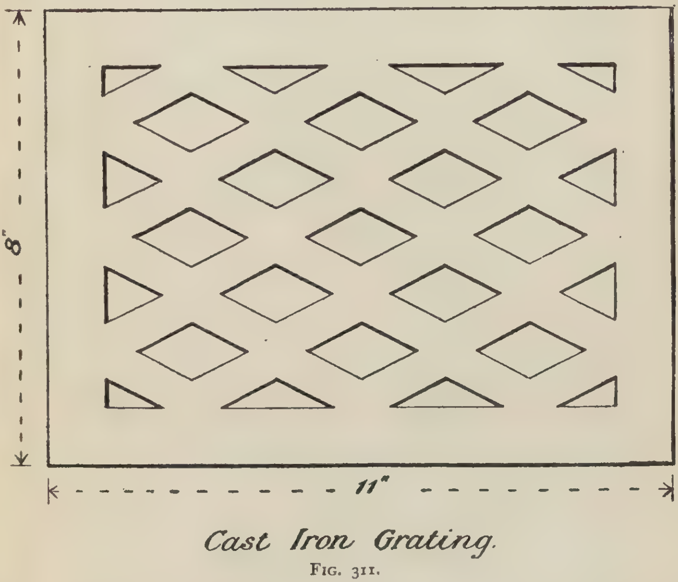

FIG. 311.

and cement, for the preparations of mortar? In what proportions and in what manner should they be mixed? (12.)

3. What materials would you use, and in what proportions, for the concrete for (*a*) the foundations under heavy walls, and (*b*) a fireproof floor in an upper storey? (12.)

4. Draw to a scale of $\frac{1}{12}$ (1" to a foot) a section through the base of an

18″ brick wall including three courses of the wall itself, with the usual footings and concrete. State how you arrive at the number of courses in the footings, and the width and thickness of the concrete. (14.)

5. Draw to a scale of $\frac{1}{12}$ (1″ to a foot) plans of two consecutive courses at the intersection at right angles of a 14″ with an 18″ brick wall built English bond. (14.)
6. Draw full size a cross section of a 2″ roll on 1″ boarding for a lead flat showing the lead in position. State how far apart the rolls should be fixed, the quality of lead to be used, and its thickness, how it should be dressed into place, and the fall that should be given to the flat. (12.)
7. Describe the nature and properties of only four of the following stones, and state for what purposes you would consider each suitable: Monks Park, Craigleith, Ancaster, Beer, Hopton Wood, Red Mansfield. (14.)
8. Draw to a scale of $\frac{1}{48}$ ($\frac{1}{4}$″ to a foot) a line diagram for a king-post roof truss of maximum span: figure the span and the scantlings of the various members. Draw to a scale of $\frac{1}{8}$ ($1\frac{1}{2}$″ to a foot) the junction of the principal rafter with the tie beam. (14.)
9. On your squared paper draw neatly one-quarter full size the section of a 12″ × 6″ rolled steel joist, and figure the thickness of the web. State the relation between the weight in lbs. per foot run, and the sectional area in square inches. (14.)
10. Draw to a scale of $\frac{1}{8}$ ($1\frac{1}{2}$″ to a foot) a section through four courses of plain tiles laid on feather-edged boarding on 4″ × 2″ rafters, pitch of roof 45 degrees. Mark the dimensions for length, gauge and lap of the tiles, and describe how they are kept in position. (12.)
11. Draw neatly on your squared paper a sketch of a jack plane: figure its real length, and state for what purposes it is chiefly used. Show the metal portions on a separate sketch, and describe how they are adjusted. (14.)
12. Draw to a scale of $\frac{1}{8}$ ($1\frac{1}{2}$″ to a foot) a section through the jamb of an internal doorway in a 9″ wall rendered on both sides, with framed jamb lining and the usual constructive details for a 2″ door. (15.)

FIRST STAGE OR ELEMENTARY EXAMINATION, 1906.

INSTRUCTIONS.

You are permitted to answer only *seven* questions.

NOTE.—*The diagram connected with these questions will be found in fig.* 312.

*1. Make a neat tracing in ink of the drawing given, with the writing; the lines should be firm and solid and should finish accurately at the proper points. (15.)

2. Describe fully what you know of blue lias lime, its origin, manufacture, preparation and the precautions to be taken in its use. (12.)
3. What are the essential properties of a good brick? Distinguish

between the following bricks, and state for what purpose they are chiefly used: Fletton, gault, red rubber, blue Staffordshire. (12.)

4. Show by a sketch on your squared paper how a pole should be slung by a rope for lifting vertically. (12.)

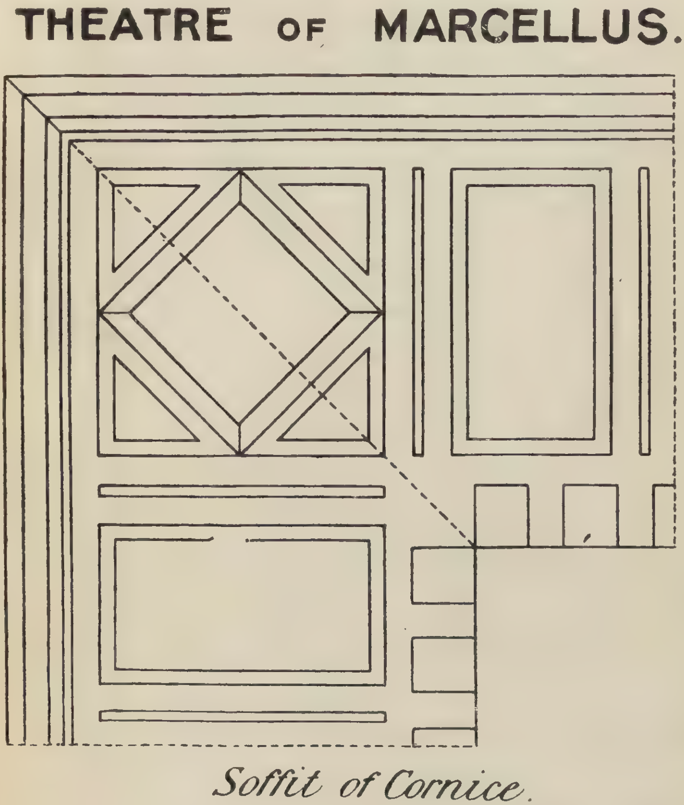

FIG. 312.

5. What is the size of a countess slate? Describe clearly and fully what is meant by "lap," and "gauge" in a slated roof, and illustrate your answer by sketches. (14.)

6. Draw to a scale of $\frac{1}{12}$ (1" to a foot) the plans of two consecutive courses of a square three-and-a-half-brick pier in Flemish bond; the joints may be shown by single lines. (14.)

7. You have the choice of the following stones in building a mansion with stables attached; state in what parts you would use them, giving your reasons: granite, Whinstone, Hard York, Craigleith, Portland whitbed, Box ground, Hopton Wood, Derbyshire marble. (14.)
8. Sketch full size on your squared paper a vertical section through the junction of two 3-inch round cast-iron rain-water pipes, and describe the method of jointing. (14.)
9. A York stone sill is described as "7″ × $4\frac{1}{2}$″, rubbed, weathered, and throated." Draw to a scale of $\frac{1}{8}$ ($1\frac{1}{2}$″ to a foot) a cross section of this sill, and describe in their proper order the operations of the mason in preparing it. (14.)
10. If lead weighs 710 lbs. per cubic foot, what is the thickness of 6 lb. sheet lead? What weight lead should be used for flats, dormer cheeks, flashings, hips and valleys, soil pipes? (12.)
11. A window opening 3 feet wide is spanned by a wooden lintel 4″ deep with 6″ bearing at each end. Draw to a scale of $\frac{1}{12}$ (1″ to a foot) an elevation of the opening and the lintel with a segmental discharging arch over it in two half-brick rings. (12.)
12. A compound girder is composed of a 12″ × 5″ rolled steel joist with a 9″ × $\frac{1}{2}$″ steel plate top and bottom. Sketch on your squared paper one quarter full size (3″ to a foot) a section through this girder; the rivets need not be shown. (15.)

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